JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXIII.] JANUARY, 1872. No. 1

EDITORIAL.

ITEMS AND NOVELTIES.

Vertical Engine.—The vertical engine shown in full-page photo-plate, by Rehn, was designed by the writer and is built by Jacob Naylor, at the People's Works, corner of Front street and Girard avenue, Philadelphia.

The base is oval in plan, with rim all around for retaining drippage from engine; on this stands a column with oval foot, bolted to the base, and with circular closed top, to which the cylinder is bolted. This column is open vertically fore and aft, to give access to all the working parts; at the lower part are formed in the casting pedestals for the shaft bearings, at the middle part the guides, and at the top the piston-rod stuffing-box, which is a separate piece, bolted in and projecting downwards to the top of the openings, the upper end of the column forming the lower cylinder head.

The crank shaft is of McHaffie steel, with counterbalance cast on, in the smaller sizes, and of best hammered iron in the larger. The fly-wheel pulley overhangs the rear bearing, which is made very long, and the rear end of fly-wheel hub is made short, so that the center of mass of wheel is well supported. The eccentric and governor pulley overhang the front bearing. In the larger sizes it is proposed to sup-

port the rear end of shaft in a third bearing, secured to an extension of the base carried around the fly-wheel.

The piston is made like Carlsund's, and is supplied with the Ramsbottom steel rings. The valve is a plain D slide. The cross-head is fitted with adjustable wooden gibs. The shaft and connecting-rod bearings (provided with compensation for wear), and the piston-rod and valve-rod stuffing-boxes and holding-nuts on valve-rod, are of copper and tin composition. The connecting-rod, piston-rod and valve-rod are of steel. The cylinder and steam-chest are clothed with wood and cased with Russia sheet iron, held by polished bands. Drip pipes and cocks are supplied to the lower ends of cylinder and steam-chest, and self-acting oil-cups to shaft and connecting-rod bearings. The steam and exhaust-pipes can be applied to either side of engine, thus making it at once right or left.

The governor is of the simplest centrifugal kind, with brass-balanced valve, and every working part of the engine is simple, strong, readily accessible and easily repaired and replaced.

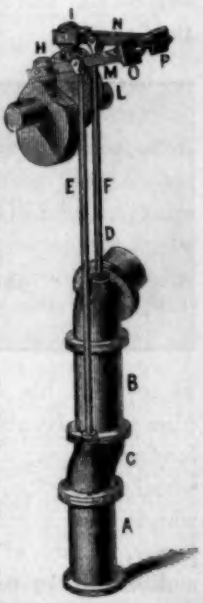
The engine as a whole is neat and graceful in appearance, occupies little space, needs no expensive foundation, is self-contained, is capable of quick movement, is not liable to derangement with ordinary attention, and is believed to combine all the modern improvements of which the single slide-valve steam-engine, without independent cut-off or condensing apparatus, is capable.

The plan of engine, however, allows the introduction of independent cut-off valve, as the Rider patent, for instance, which is the simplest and best, and of course the cheapest, since it consists simply of the addition of one eccentric and rod, one valve stem guide and swivel, and one slide-valve, of peculiar yet simple construction, working on back of main slide, but with no liberating and arresting gear. It is proposed to apply this cut-off to the larger sizes where the saving of fuel would warrant its introduction. J. H. COOPER.

An Equable Pump, *or Machine for Raising Water without Interruption or Concussion.*—"It is composed of two barrels, A B, both of them forming part of the column of water to be raised, connected together by a crooked tube, C, of equal diameter, out of which the lower piston-rod passes through a stuffing-box into the air, as does the upper piston-rod at D, where the column leaves the pump to pass upward. The two pistons fixed to the rods E and F are of the bucket kind, made as thin and light as possible, their valves opening upwards, and their motions being such, generally, that when one of

them is drawn up the water rises through the other, then descending. But here lies both the novelty and utility of the machine; these up-upward and downward motions are not reciprocal. Both pistons fall faster than they rise, and thus leave an interval of time, *when they both rise together*, during which their valves, respectively, close by their own weight *before* the column of water falls upon them; in such manner, indeed, that the column never *falls* at all. By this important arrangement the work is constantly going on, and *no commotion* occurs to absorb *power* uselessly, or to destroy, prematurely, the machine—circumstances which constantly attend every pump machine acting by merely reciprocal motion.

This non-reciprocity, then, I produce by several methods, one of which (perhaps the most easily understood) is that shown in the cut:



"Thus, H I are two friction-rollers, made as large as possible, rolling on pins in the ends of the levers M N, to which the bucket rods, E F, are attached, and tenons on the other ends hold these ends stationary in mortices, and on the curves J K, the ascending and descending parts of which are essentially *unequal*. For example, the rising part of the curve occupies $\frac{2}{3}$ of the whole circumference, and the falling part $\frac{1}{3}$ only; so that both curves recede from the center at the same time, during $\frac{1}{6}$ of a revolution.

"Applying, then, these curves and levers to the pump-barrels, we obtain that *continuity of uniform* motion which is necessary to doing the greatest quantity of work with the least power, and to securing the greatest durability of the machine. Having hinted at a *minimum* of power, I must add here that this machine appears to promise that result, much more credibly than any reciprocating pump whatever, especially if to this continuity of motion we add a certain *largeness* of dimension that shall produce the required quantity of water with the slowest possible motion of each particle; and even here this *continuative* principle helps us much, since pistons and valves of the largest dimensions may be used without introducing any convulsive or (what is synonymous) any destructive effects.

"One particular remains to be noticed. It relates to the means by

which the *perpendicularity* of the motion in the piston-rods is secured. The arcs, O P, are portions of cylinders having the centers of the pump-rod connections in the levers for their centers, and which, *rolling* up and down against the perpendicular plane into which the end tenons fit, secure a vertical motion to the pump-rods.

"It should be observed that the present machine was executed in France in 1793 or 1794, and also proposed to the government as a substitute for the celebrated machine of Marly. In the report then published it was preferred to the whole multitude of former projects."—*Century of Inventions.* James White. 1822. J. H. C.

An Inclined Horse-Wheel.—"My principal inducements for giving this wheel the form represented by a section were to save *horizontal room* and to gain speed by *a wheel* smaller than a common horse-walk, and yet requiring less obliquity of effort on the part of the horse.

"With this intention the horse is placed *in a conical* wheel, A B, more or less inclined, and not much higher than himself, where, nevertheless, his head *is seen* to be at perfect liberty out of the cone, as at C. The horse then walks *in* the cone, and is harnessed to a fixed bar introduced from the open side, where, by a proper adjustment of the traces, he is made to act partly by his weight, so as to exert his strength in a favorable manner. This machine applies with advantage where a horse's power is wanted *in a boat or other confined place;* and it is evident, by the relative diameters of the wheel and pinion, A B and D (as well as by the small diameter of the wheel), that a considerable velocity will be obtained at the source of power, whence, of course, the subsequent *gearing* to obtain the swifter motions will be proportionately diminished."—*Century of Inventions.* James White. 1822. J. H. C.

Utilization of Coal-Dust.—Mr. E. Loiseau, of Philadelphia, recently submitted to the Institute samples of blocks and balls of bituminous and anthracite slack; made by thoroughly mixing with the fine coal about seven per cent. of clay; the object of the inventor being to present a cheap method of utilizing the immense quantities of waste or slack, which are the attendants upon mining

operations—an idea which has already called forth a number of inventions.

The lumps prepared, as already stated, are dipped into a bath of benzine, in which rosin has been dissolved. The object of this operation is to render them impervious to moisture. The solution penetrates the lumps to the extent of about a quarter inch; and upon the evaporation of the benzine, which takes place rapidly upon exposure to a current of air, a film of rosin is left behind, which so effectually stops up all crevices, that in the experiments made by the Committee on Science and Arts in investigating the process, masses which had lain in water for twelve hours were found to have lost none of their compactness and to be still dry in the interior. The consumption of the artificial fuel took place very satisfactorily, all the specimens burning till completely ashed.

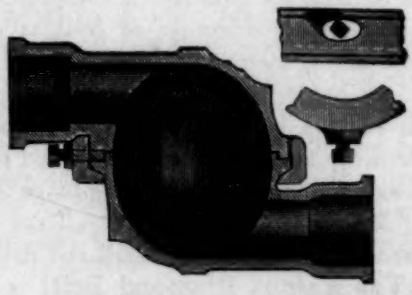
With regard to the heating power of the material, the committee's report show this to be somewhat below the average of bituminous or anthracite, as would naturally be anticipated from the admixture of clay. The compactness of the material will, in their opinion, allow of its transportation, with ordinary handling, with as little loss from breakage, as is suffered by many kinds of bituminous and semi-bituminous coals which are brought to market.

It would seem, therefore, that the plan of Mr. L. is one of the most practical which has yet been made public for utilizing this waste product. Its ability to withstand disintegration by the action of rain is certainly a great point in its favor. The main question after all, however, resolves itself into one of economy, and it is clear that, however well adapted it may be for many purposes in the arts, no artificial fuel can ever become of practical value to consumers, until the cost of its preparation is less expensive than the cost of mining coal. Should this prove to be the case with the plan here described, it will doubtless prove in every way worthy of the attention of those interested in the production of a cheap fuel.

The Patent Diamond Drill is a tube of iron, like gas pipe, the lower end of which is faced with small diamonds. The drill generally stands upright, but may be used in other positions. We speak here of the vertical drill. The drill is revolved rapidly by steam machinery, and is fed downwards into the rock by a screw-feed, somewhat in the manner of a drill in an ordinary drilling press used in machine shops. The hole cut by the drill is a *ring*, leaving a *core* standing inside of the tube. To prevent heating by friction, a con-

stant stream of water is forced down the inside of the tube, and reascends outside, bringing up the dust or borings. The steam engine used to actuate the drill resembles in general appearance an ordinary portable steam hoisting engine. The cylinders and the machinery are bolted to the vertical face of the end of the boiler. The apparatus for turning the drill, feeding, and causing the drill to return out of the hole when desired, is ingenious and effective, but need not be minutely described here. The writer saw a two-inch hole put down about two feet into hard rock, perhaps at the rate of four feet per hour. The diamonds are said to last a long while, and to be self-sharpening. The hole, for small holes, may be about three-quarters of an inch more in diameter than the core; in large holes the difference is probably somewhat greater, but the proportion of the diameters more nearly equal. The core of small holes breaks off by raising the drill, and there is an ingenious and effectual method of causing the core to come up with the tube when the tube is withdrawn from the hole. It is said that large cores are broken loose at the bottom by means of blasting, the cartridge being sent down the hollow ring left by the drill. J. W.

Steam-Pipe Joint.—We subjoin an engraving showing a neat form of flexible joint for steam-pipes, designed by Messrs. Wöhrman & Son, of Mülenhof, Russia, and which has been successfully employed by them for the pipes of steam pile-driving machines.



In spherical joints, as ordinarily constructed, the pressure tends naturally to force apart the surfaces which fit together, and which form the steam-tight joint.* In the engraving here illustrated this action is reversed, the pressure of the steam tending to force the joint surfaces together.

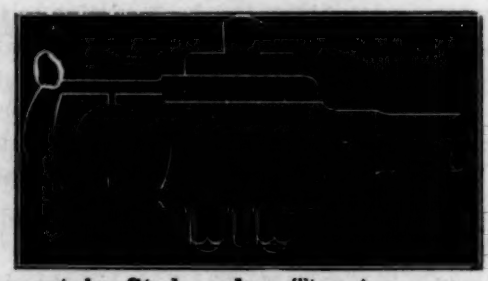
The illustration herewith presented explains the construction and operation so clearly that a further description is unnecessary. The joint is declared to answer well, and there are many situations where it could doubtless be usefully applied.

* English Mechanic, xiv, 246.

Light Railways*.—A wooden railway, four feet eight and one-half inch gauge, is being constructed in the province of Quebec, Canada. The rails are of maple, four by seven inches, and fourteen feet long; the ties are of hemlock and tamarac.

The cost of the line, thirty miles long, including nine stations, car and locomotive depot, engine and repairing shops, engine and tender, two passengers cars, eight grain cars and twenty-five wood cars, is $5,000 a mile, including all damages.

An experimental trip has been made on the completed portion of the road, the train going at the rate of twenty-five miles an hour and with remarkable smoothness.



Improvement in Stub-ends.—The above cut represents the stub end as designed by Mr. John Fritz, for the large engines he is making for the Bessimer plant of the Bethlehem Iron Co., at their works at Bethlehem, Pa. The cut explains itself. It may be observed that the gibs used in each side of the key, are made with heads which project side-ways as well as end-ways, and the washers and nuts at the lower end of gibs also cover as much surface on the strap as do the heads. The gibs are, in fact, through bolts, and while they answer the purpose for which they are required, they serve to bind the strap firmly to the stub end, and prevent the loosenesss from wear consequent upon the use of gibs as ordinarily made. This practice of Mr. Fritz, seems to have all the merit of the through bolts as used by locomotive engineers, and the gib and key as used on stationary engines. COLEMAN SELLERS.

A Hard Cement.—The Abbe Moigno† relates a circumstance which may contain a valuable hint in relation to the use of cement. A workman employed to repair the steps leading to a garden, made use of Portland cement mixed with finely divided cast and wrought

*Technologist, Dec., 1871.
† Les Mondes.

iron filings, or fragments, in place of sand. The result is stated to be, that the mass has become so hard as to resist fracture, either with the hammer or pick-axe.

A Novel Patent.—As a substitute for gunpowder, J. Fournier has patented, in England, the following curiosity: 125 grms. carbonate of lime; 65 grms. salt; 35 grms. of charcoal and as much wine as is necessary to cover these materials in a vessel.

The attention of our readers is invited, in this connection, to the very sensible remarks of Mr. J. Richards upon the subject of patents. Surely no better argument for the necessity of thorough reformation of the system of patent laws could be desired than is afforded by the possibility of the committal of a blunder so glaring as the patenting of an "invention" so palpably and laughably absurd as this.

Welding Copper*.—A mixture composed of 358 parts of phosphate of soda and 124 parts of boracic acid is recommended by Mr. Rust as an admirable one to insure the perfect welding of copper.

The powder should be applied while the metal is at a dull red heat; it is then brought to a cherry-red and at once hammered. Owing to the tendency of the metal to soften after exposure to a high heat, a wooden hammer is recommended which is to be applied very gently. All carbonaceous matter must be carefully removed from the faces to be joined, since the principle of the operation depends on the formation of a very fusible phosphate of copper, which would be reduced by carbon to the condition of a phosphide. The action of the substance recommended depends upon the ability of the phosphate of copper formed, to dissolve the thin film of oxide on the surfaces of metal, keeping them thus perfectly clean and in condition to weld.

A New Hygrometer.†—Mr. Woodbury proposes to utilize the color changes which, as is well known to chemists, are produced in the chloride of cobalt on exposure to different degrees of moisture, for the purpose of hygrometric measurement. For this purpose the inventor treats sized paper with a strong solution of chloride of cobalt, to which has been added a small quantity of common salt and gum arabic. This will retain a blue color in a dry atmosphere, but will change through all the gradations to pink, as the air becomes moist to damp. In order to construct a scale for reading these indications, the inventor draws on a card two circles, one considerably

* Am. Ex. and Review, Dec., 1871.

† English Mechanic, xiv, 302.

smaller than the other, and in its centre. In the annular space left between the two, the various gradations of color, from blue to pink, are arranged radially, which being accomplished and the degrees of moisture marked, a piece of the prepared paper is placed in the inner circle, and the changes which occur can be thus conveniently read.

Sodium as an Explosive Agent.*—A contemporary calls attention to the fact that experiments upon the application of sodium as an explosive, which were originated, we believe, some years ago by Prof. Wurtz, of New York, are about to be recommenced.

In this connection it may be interesting to describe briefly the *modus operandi* followed in these earlier experiments. The theory of the plan here proposed, rests upon the great expansive force which will be exercised upon the walls of a vessel in a confined space, this force being readily called into operation by the hydrogen suddenly evolved in the decomposition of water by the sodium.

The device by which this may be utilized in practice, is described as consisting of two glass bulbs which are blown with a neck between them. One bulb is filled with sodium, the other with water—while in the neck connecting them a soluble salt is previously fused. The time required to fire the charge can be regulated at pleasure by the varying size or length of the neck. With this arrangement the apparatus is lowered into the drill hole, the sodium being below. The salt is gradually dissolved by the water and as this comes into contact with the sodium the explosion ensues.

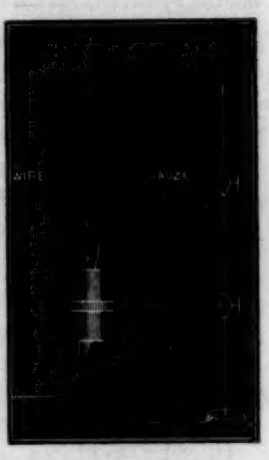
In order to utilize the theoretical value of the charge it would be necessary that all the sodium should be expended in the decomposition of the water. How far this is accomplished in the arrangement just described, it is impossible to state with any certainty. But though it may be found to operate with good effect, it is clear that but a fraction of the possible power can be thus obtained, as the explosion will ensue before the sodium is completely utilized. The principle is, however, ingenious, and with such improvements in its application which a few practical trials will readily suggest, may prove in time a valuable addition to the art of blasting.

The Manufacture of Platinum.—In relation to this subject in one of the former issues of the Journal, the erroneous statement was made that there was but one establishment in the country for the manufacture and working of platinum. The statement, we have

* Journ. App. Chem., Dec., 1871.

since learned, is incorrect, and we now gladly add to the notice of the establishment formerly referred to, that of Mr. Joachim Bishop, of Chester County, in this State, whose announcement will be found amongst our business notices. We are informed that Mr. B. was for a long time the assistant of Dr. Hare, of this city, and that he has, for years, been making good use of the Doctor's discovery of the oxy-hydrogen blow-pipe.

New Form of Sensitive Flame.—Mr. Phillip Barry has sent a description of the accompanying new form of sensitive flame to Prof. Tyndall*.



The plan adopted consists in igniting the gas (ordinary coal gas) not at the burner, but some inches above it, by interposing between the burner and the flame a piece of wire-gauze.

The accompanying figure represents the arrangement. The space between the flame and burner being about two inches, the wire-gauze (composed of thirty-two meshes to the lineal inch) resting on the ring of the retort-stand, and being about seven inches square.

The flame is described to be a slender cone about four inches high, with the upper portion luminous and the base a blue flame. It is asserted to be the most sensitive of all sensitive flames, roaring at the least noise and sinking down to the surface of the gauze, becoming at the same time almost invisible. Being very active in its responses and rather noisy, its sympathy is apparent to the ear as well as the eye. See p 229

Manufacture of Hydrogen.—H. Giffard† has constructed an apparatus, the details of which are not specified, for the manufacture of hydrogen gas. At the works of M. Flaud, in Paris, where it was tested, the gas was obtained at the rate of about 70 cubic feet per minute.

The inventor passes steam over red hot iron, which, when nearly exhausted by oxidation, is reduced again to the metallic state by the action of a current of dry carbonic oxide gas.

* Nature, v, 106.

† Les Mondes, Oct. 13th, 1871.

A plan of this kind is perfectly rational, but to be worked with economy, it is necessary that the carbonic oxide used to revivify the exhausted iron should be generated at a lower cost than that of fresh iron. How it is produced in this case we are left to guess. It is more than probable, however, that a slow current of air is allowed to pass over an extended surface of glowing coals.

Experiments in the Mont Cenis Tunnel.—The Mont Cenis tunnel will perhaps be found of service in more ways than the one for which it is designed. Recent exchanges inform us that several *savants*, Pater Secchi amongst the number, are preparing to make it the scene of a number of physical investigations, which will include gravity measurements with the pendulum, observations upon magnetism and on temperature of the rocks. These experiments will be made in the tunnel itself, as well as upon the mountain through which it is bored.

It has already been ascertained that the passage of trains will not sensibly vitiate the accuracy of the proposed observations.

A Paraffin with a high Melting Point.—John Galletly* announces that he has obtained a paraffin having a melting point at 80° C. (176° Fahr.). The product was obtained in an impure residue from the manufacture of paraffin from Boghead coal. Its properties are thus described. It resembles beeswax in appearance, though more translucent and without the conchoidal fracture of this substance. It is crystalline; its melting point is as above stated, and it boils at a point but little below red heat, thereby undergoing partial decomposition. A candle made of this high melting paraffin burns with a clear smokeless flame, and lasts a long time. The new product may in time become of importance in the arts.

New Method of Observing Absorption Spectra.—E. Sommel† suggests the use of gelatin sheets in place of glass vessels in observing the absorption spectra of soluble coloring matters. The gelatin sheets are simply colored with the different substances, and permanently attached between two colorless glass plates. In this way quite a collection of different coloring matters may be made, which we are informed are quite durable. The alteration of the absorpsion spectra from the varying intensity of the solution, can be shown by imposing a number of the colored sheets upon each other. The

* Chem. News, xxiv, 187.

† Pogg. Annalen, clxiii, 656.

method is a simple one, and certainly far more convenient than that ordinarily used.

Railway Dust.—Mr. Jas. Sidebotham* has published a communication upon the composition of railway dust; having collected a quantity of the material by spreading a newspaper near an open window in a railway carriage, and subsequently subjected it to a microscopical examination. A large proportion of the fragments were found to be iron. They were mostly long, thin and straight, the largest being about ·150 inch, and had much the appearance of old nails. Of the original quantity collected (57 grains) one-half of it (29 grains) were removable with the magnet, and consisted therefore of iron.

The other portion of the dust consisted largely of cinders, some bright angular fragments of glass or quartz, a few bits of yellow metal, opaque white and spherical bodies, a few bits of coal, etc. The character of its constituents affords a satisfactory explanation for the irritating effects on the throat produced after inhaling the material.

Estimation of Graphite.—F. Stolba† communicates the fact that it is possible to determine, accurately enough for practical purposes, the percentage of carbon in commercial graphite by simple combustion in the air. He employs for this purpose a simple Bunsen burner, and announces that the burning of a few grammes of graphite is by no means so difficult as is generally supposed. The author places a weighed portion of the finely powdered and dried material in a platinum crucible, having a punctured cover. The crucible is placed over the flame in an inclined position, and the cover is placed so as to leave one-fourth of the same open. By this arrangement, by which a good draft is secured within and occasional stirring of the material, a few hours completes the operation, leaving the ash in an excellent condition for further analysis.

A Source of Error in Spectroscopy.—M. Blaserna‡ has made an interesting observation upon the influence which the temperature of the prism exercises upon the position of the lines. It has already been noticed by Verdet that where liquids are used for prisms the displacement of the lines is quite noticeable, the index of refraction altering with the temperature.

* Proc. Lit. and Phil. Soc., Manchester.
† Dingler's Journal, cxcviii, 213.
‡ Pogg. Ann., cxliii, 655.

For solid prisms, however, it was assumed that the influence of temperature changes upon their refractive power was quite insignificant. The author has found, however, upon observation, that this is not so unimportant as is generally believed; but that, while much less sensitive than liquid prisms, the displacement of lines could readily be observed with one of flint glass. The prism used in the experiment was one of Duboscq's, and was exposed for some time to the direct rays of the sun. It was then quickly placed in a spectroscope in the shade, and some prominent line observed, when it was found that as the glass cooled the refractive power increased. (An opposite result is obtained for bisulphide of carbon.) He was enabled to observe in this manner a displacement of the D line amounting to 3″ for a difference in temperature, equal to 1° Cent. In the instrument used the interval between D and D′ is 12″, so that a change of 4° C. would suffice to place D in the position of D′. The author remarks, as the result of his interesting observation, that an error might very readily be made in spectroscopic work by comparing together observations made in sunlight and in shade, or those made in the morning with those in the night.

Passivity of Cadmium.—Dr. Schönn announces that the metal cadmium may, under certain circumstances, be rendered indifferent to the action of acids. It has long been known that iron, if plunged into this acid of a certain degree of concentration, acquires a peculiar surface condition, rendering it indifferent to the action of the strongest acid. Iron which has undergone this surface change has been termed passive. It appears, too, that such iron has acquired some peculiar physical qualities, since it will form a galvanic circuit with ordinary iron; the changed metal behaving electrically negative to the other. That such iron has really been decidedly altered in character is evinced again by the fact that it refuses to reduce copper from solutions of its salts.

It appears, from Dr. Schönn's observation, that if cadmium is wrapped with some platinum wire, it may be placed, without being in the least acted upon, in strong nitric acid; though if the wire surrounding is removed, or if the acid is diluted, the cadmium is instantly attacked, thus showing that the passivity of the cadmium is due entirely to its contact with the platinum. The same author has shown that tin will give the same phenomenon.

Action of Light on Cane Sugar Solutions.—M. Raoult* communicates the fact that a solution of cane-sugar may be converted into grape sugar (glucose) under the influence of light. The observation was made in the following manner:

A concentrated aqueous solution of cane sugar was placed in glass tubes, which were sealed while their contents were boiling. These were placed near each other, under the same conditions, with the sole difference that one was kept in total darkness, while the other was exposed to the bright daylight. Several months later the tubes were examined, when both solutions were found, under the microscope, to be free from vegetable matter. The solution, however, which had been in the light, at once gave an abundant red precipitate with a copper salt on addition of a free alkali (the test for grape sugar); while the contents of the tube kept in the dark, gave no sign of the reaction.

A new Reagent for Copper.—Mr. Hugo Tamm announces that a mixture of the sulpho-cyanide of ammonium and bi-sulphite of ammonia in equal parts, which will keep for several months in aqueous solution without decomposition, is an admirable reagent for copper. It is volatile, and can therefore be driven off completely on evaporation to dryness, it forms a very insoluble pulverant precipitate, a white sub-sulpho-cyanide, which can readily be washed, and it affects scarcely any other metal which may happen to be present.

The Source of Nerve Force.†—Mr. J. St. Clair Gray is the author of a view concerning the origin of nerve force, which he is very judiciously endeavoring to verify by actual experiment. The author, starting from the assumption that this power had in it an electrical element, arrived finally at the conclusion that its source is to be sought for in the sulphur and phosphorus in the animal system.

It is well known that phosphorus exists in considerable quantity in the brain, and that sulphur is present in the liver, while an alkaline fluid is in constant circulation between them.

To determine the fact as to whether a combination of similar elements would generate an electric current, he constructed a cell containing caustic potassa, in which were placed sticks of sulphur and phosphorus. Chemical action very soon set in. The phosphorus was soon converted into an oily mass, the sulphur gradually wasted away

* Comptes Rendus, Oct. 30th, 1871.
† English Mechanic, xiv, 317.

at the point of contact with the former, while potassa salts were formed in the solution. The operation was attended with the evolution of phosphuretted and sulphuretted hydrogens.

The action seems to be very gradual, since we are informed that at the end of three months it was still going on. The presence of an electric current in the cell was conclusively established by the electrometer, the electro-motive force of the current being found to be superior to that of the Daniell cell.

Having thus established one fact in favor of his hypothesis, the author next proceeded to test its truth under the actual conditions of life. The leg of a frog was prepared as a galvanoscope according to Galvani's directions. A rabbit was then chloroformed, and through an incision in the abdomen an insulated copper wire was introduced into the substance of the liver, and another similar wire passed through the optic foramen into the brain. The free ends of the wires were then brought into contact with the exposed nerve of the frog's leg, when powerful convulsions were produced in it; a very clear demonstration that an electric current does exist between the brain and the liver. From these facts the author infers that the source of the current is the action of the alkaline fluid on the sulphur and phosphorus in these organs; especially since he has shown, from his experiment with the cell constructed on this principle, that the combination of these elements is capable of generating a very powerful current.

The experiments are still being continued, and we shall doubtless soon be informed either that subsequent investigation has disproven this ingenious theory, or that the source of nerve-force is discovered. The very obvious objection that sulphur and phosphorus do not exist *as such* but as compounds, in the liver and brain, must, of course, be considered as militating against the author's views, until it is shown to the contrary.

Editorial Correspondence.

Brick-dust Cement.

PHILADELPHIA, Dec. 20th, 1871.

To the Editor of the Journal of the Franklin Institute.

DEAR SIR—It may not be generally known among builders in this country, or to the majority of your readers, that in the Spanish do-

minions ordinary brick-dust, made from hard burned, finely pulverized bricks, and mixed with common lime and sand, is universally and successfully employed as a substitute for hydraulic cement.

The writer, during an engineering experience of six (6) years in Cuba, had ample opportunity for testing its merits, and found it in all respects superior to the best Rosendale hydraulic cement for culverts, drains, tanks or cisterns and even for roofs; whether for setting flat tiles, or for making the usual tropical concrete flat roof.

It is regularly known there as an article of commerce, sold in barrels by all dealers in such articles at the same price as cement. The proportions used in general practice are one of brick dust and one of lime to two of sand, mixed together, dry and tempered with water in the usual way. A greater or less quantity of the brick dust is sometimes employed when considered desirable. The writer cannot say whether this composition has ever been tried in this country, or whether it would retain its virtues when subjected to the action of frost.

It would seem, however, that it could be produced at a lower rate than cement, by the addition of pulverizing mills to our brick yards to utilize the waste and broken bricks; and if found successful, its manufacture might be worth considering by those who are interested in such products.

Very truly yours,

F. B. Miles.

Note.—Under the paragraph headed Hydraulic Cements in Trautwine's Engineers Pocket-book (recently published) mention is made of the same material; from which it appears that it is considerably used in France. The author of the work in question pronounces it, from his own observation, to be decidedly hydraulic—a block of the same one-half inch in thickness, without sand, after immersion in water for four months, bore, without crumbling, crushing or splitting, a pressure of 1500 lbs. per square inch. The opinion is further expressed that the addition of even as little as one-tenth as much brick dust as sand to our ordinary mortars, would prevent the disintegration so generally visible in the mortars used in masonry.—Ed.

Civil and Mechanical Engineering.

PATENT INVENTION.

By J. Richards, M. E.

When any public interest becomes the subject of controversy, when widely different opinions are drawn from apparently the same premises, it is generally safe to assume that there is some inherent error that lies at the bottom—some principle that is at variance with the laws of political economy, or of science, as the case may be. With this proposition I beg briefly to consider the subject of patent inventions, in view of the present agitation of the matter in England and the United States.

Our courts have for two centuries puzzled their brains to define what constitutes invention—where devices or combinations end, and where principles begin; to define what principle means, as applied to machines, &c., &c.

Our legislators have grappled this knotty subject of property in invention (as is plainly their duty); long harangues are the result. A commission costing thousands of pounds has, in England, been set at work to unravel this troubled question of patents.

The history of the Netherlands, with their mechanical achievements of two centuries ago, are dragged into the argument; men skilled in procuring patents are placed at the bar to give testimony as to the patent system. (The writer must, however, be careful in reviewing this matter, as he has not mustered the courage to go through the proceedings of the commission.)

Now, Mr. Judge or Legislator, is it not possible that there is something behind all this trouble about patents that has been lost sight of, and are you not trying to frame *civil* laws to govern that which belongs to the field of *science?* Has not the demonstration of the mechanical equivalent of heat, the laws of forces, laws of construction, &c., under the rapid advances of the few last years, "undermined" your old theories about property in invention?

Assuming the proposition given at the outset to be true, the writer as an engineer and patentee of numerous inventions, begs to submit the following views in regard to patents, which, so far as he knows, have not been embodied in any of the very able discussions heretofore had on this subject, trusting that, whether true or erroneous, they

will contribute something to the settlement of a question in which he feels a great interest.

To present his views in a manner intelligible to all, the following propositions are submitted:

First. Invention, in accordance with the general acceptation of the term, means "discovery," a finding out of something not known before, not by consecutive deductions from certain known premises, but a kind of "accidental" discovery. It might also be said to mean a kind of "intuition" that reveals what is sought through a faculty called genius.

Second. Demonstration by deductions from known premises or data, wrought out by mathematical or engineering knowledge, is not invention in the sense above, nor can it be comprehended in the intent of the law relating to discoveries or inventions.

Third. The necessity for, or even the very existence of such a thing as invention or discovery, in the popular sense, is found wholly in our imperfect knowledge of scientific law, and the age in which it was found to be expedient or necessary to offer *bribes* for such discovery has passed away.

In reference to the first proposition, it is hardly worth while to offer anything in its support, that inventions means in a popular way a kind of "chance finding out" none will dispute. It has ever been regarded as a kind of supernatural gift. Inventions have had thrown around them the cloak of secrecy, and the public mind has always been educated to a kind of mystery in regard to patents.

Think of a State offering premiums to its subjects for the discovery (not demonstration) of a "perpetual motion," whatever that may be. Think of the thousands of pounds and the hundreds of useless lives that have been sacrificed on this altar of mechanical discovery, and we must go far back to the dark ages of alchemy and superstition to find a parallel.

The second proposition, as to what does not constitute invention, is more important. In its support no stronger argument can be adduced, nor even wanted, than the trouble that has ever existed to define what constitutes invention, such invention as could by right become the property of the individual. It has been held that such invention must not comprehend a principle; next, a principle must be defined, which we are told is a "mode of operation," and that the devices may be claimed but not their "manner of operating;" but then these devices we claim are, of necessity, mechanical agents, gen-

erally known both to practice and philosophy. Yes, true, but there is the combination of these elements that is proper subject-matter for a patent and exclusive right. Grant that, but it is further held that at least one element in a particular combination must be new; "new" in what sense? there is rarely a new mechanical movement discovered; new in the sense of not being known to the laws of physics, and there can be no new element among mechanical devices in these combinations.

We are also told that a combination of old elements to produce a new result is proper subject-matter for a patent, which, like the former assumption, if followed out ends at the same point, just where it began, and has no meaning that is sufficiently tangible for the mind to grasp. The inevitable conclusion is, there is *nothing* in invention which can of right become the property of the individual, for the want of our power to define it. If there is anything to which he has a natural right it could certainly be so defined as to come within the scope of ordinary comprehension.

Results attained, then, by deductive reasoning are not inventions—not discoveries at least in the accepted sense, for two persons with similar premises will attain like results in pursuit of a given object; the premises—laws—data—or whatever else we may term them, are open to all. The scientific or practical attainments of the inventor are but borrowed from popular sources, and the experience and knowledge of others, hence results or demonstrations, inventions if you please, thus wrought out cannot of right become the property of the individual, and cannot certainly be the intent and meaning of the statute relating to invention.

The third proposition is a bold one, no doubt, but nevertheless true in the abstract, so far as relating to mechanical invention, at least; every invention or discovery in mechanics must, of necessity, be found to conform to the laws of science. The difference, then, between what we will term "legitimate" and "illegitimate" invention, is that in the one case the result is discovered by tracing it out through the medium of these laws, as from cause to effect; in the other by groping about until, by chance, we light upon the result, and then by a negative course *follow back* these laws to prove its conformity with physical science; to make a plain illustration, it is like making a search for the missing end of a thread, in one case groping about to find it by accidental discovery, in the other by following the thread itself to the missing end.

To show by a more familiar example that this proposition is not a chimerical one, let us suppose that an existing fault or want has been demonstrated. This fault or want we will suppose, for example, to be the tendency of railway trains to overturn in making sharp curves. Let us next suppose two inventors, one of the illegitimate school, setting about to "discover" a remedy, without scientific knowledge, but with the incentive of "personal right" in his discovery when made; the other, an engineer educated in the laws of physical science and construction, moving in the legitimate performance of his professional duty.

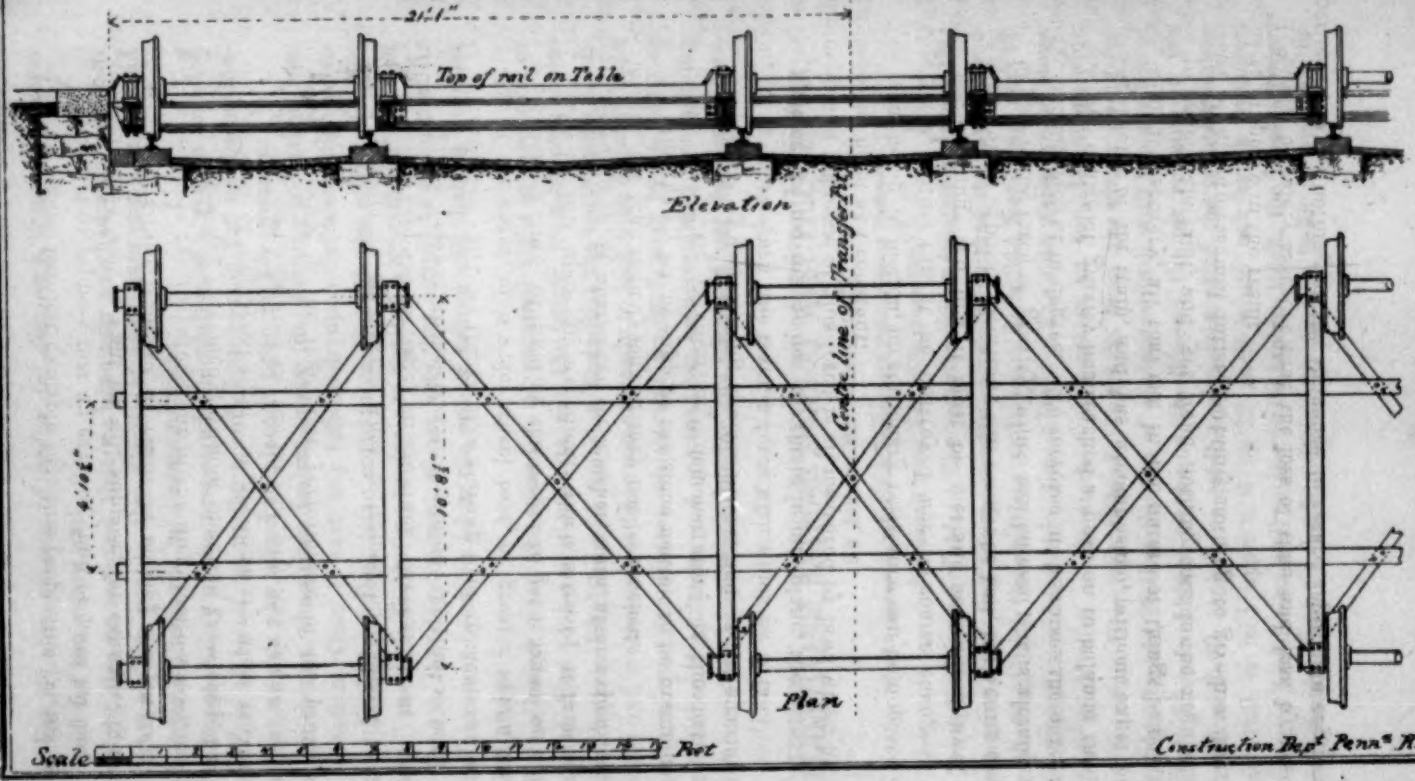
The first commences by tasking what is termed his "ingenuity" for expedients to keep the carriages on the track. Mechanical devices of various kinds present themselves to his mind; he thinks of gib hooks beneath the rail; he thinks of a shifting load to move to the short side of the curve, of a wider wheel base, of greater weight to keep the carriages down, of lowering the weight to get it between the rails; finally he hits upon an expedient which is *tried;* it fails, is modified, *tried again*, is abandoned for another, until, after expensive experiments, the true remedy may or may not be reached.

On the other hand, let us suppose the same matter to be taken in hand by the legitimate inventor, or "demonstrator" is the better term. He begins by ascertaining the conditions, finds a force acting which tends to overturn the train, a force with which he is familiar, as the tendency of moving bodies to remain in one plane, the extent, direction and influence of this force is all measured by laws which he knows to be fixed and constant.

The train being in motion, no stationary resistance can be opposed to this force, neither can it be destroyed nor its course changed; hence his teachings tell him it must be met and neutralized by a force acting in an opposite direction; this cannot be had, but acting at right angles is the force of gravity, which can be used; it is already acting, but insufficient in degree. To increase it he raises the outer rail until the centre of gravity has reached a position to balance the centrifugal force of the train, and has accomplished, without experiment, without discovery, all that can in the nature of things be possible to remedy the fault, and yet done nothing outside the regular exercise of his professional duties, certainly nothing to give him the right of property in the result.

It might be safely asserted that the loss of time and loss by experiment, to say nothing of the influence to retard legitimate engin-

Pennsylvania Railroad Shops, West Philadelphia, Transfer Table



eering, has, by this system of *bribes for discovery*, done more harm than good for ten years past.

It might also be assumed that we have now reached a period when the rights of the people, the dignity of legitimate engineering and public interest demands its discontinuance.

The impossibility of the proper administration of a system founded in error, is of itself no doubt a sufficient reason for its discontinuance, but we can now afford to place it upon higher grounds.

In conclusion, the writer desires to say that nothing is further from his intention than to cast any reflection upon the many highly important inventions that have come to us through the school of "discovery," nor is it the intent to declaim against a system that has had its place in the development of our arts, but simply to claim that its faults have not been traced to the proper source and that its time has passed away.

We no longer need the incentive of personal right in invention or demonstration to develop our arts, and the writer, from his own observation, both in England and America, finds that the better class of engineers and mechanicians have come already to look with disfavor upon patents, a question of fact which will be confirmed by as many as have noticed the matter, and one that can be determined by searching the records of the patent office for the names of our best engineers.

PENNSYLVANIA RAILROAD SHOPS AT WEST PHILADELPHIA.

By Joseph M. Wilson, C. E.

P. A. Engineer Construction Department Pennsylvania Railroad.

(Continued from Vol LXII. page 320.)

Transfer Pit and Table. The transfer pit is located between the locomotive shop and the passenger car shop, so that it may be used for shifting both locomotives and cars. It is 244 feet long and 42 feet 2 inches wide, inside dimensions. The side walls are of stone 2 feet thick, with a cut stone coping course on top, 18 inches wide and 9 inches deep, the rails of the tracks from the shops being cut into this coping, so that the top of coping is flush with top surface of rails. There are three tracks on the floor of the pit running in the direction of its length, to guide the movement of the transfer table. Each rail is laid upon a 6 by 12 inch white oak track stringer, having a foundation wall under it 20 inches thick, the track stringer being firmly fixed to the foundation by anchor bolts at frequent in-

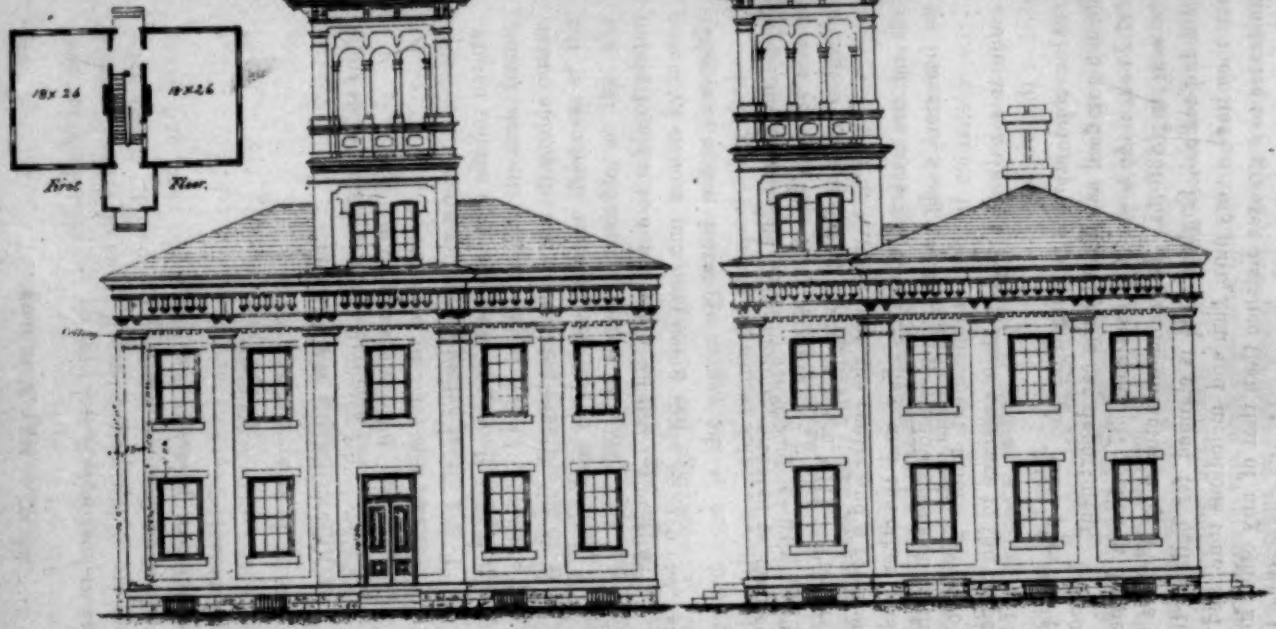
tervals in its length. The floor of the pit is paved with brick laid flat in sand, the proper grades being given to the different parts, so that surface water may drain off into sewer openings provided for the purpose at three points in the length of the pit.

The transfer table, designed and manufactured by Williams Sellers & Co., of Philadelphia, is constructed entirely of wrought-iron, except the wheels, which are the usual cast-iron wheels used on American roads. Plate XII gives a plan and elevation of this table. The table proper, which is suspended from six pairs of wheels, is built of rolled heavy 9 inch I beams, weighing 150 lbs. to the yard. There are six cross-beams suspended from the wheel axles, and two longitudinal beams, one under each rail of the track on the table. The top flanges of these beams are in the same plane, and where the beams meet, those running longitudinally are cut and connected to the others by splicing plates and rivets. Diagonal plates, 1 inch by 4 inches pass underneath, being riveted to the flanges of the beams wherever they pass them, thus thoroughly stiffening the structure laterally. The rails on table are laid directly on to the longitudinal I beams and bolted fast. The height from base of rail on table to base of rail on floor of pit is 14¾ inches. The length of table is 42 feet, an allowance of one inch being made at each end, less than the width of the pit, for clearance.

Office Building. The office building, situated as marked No. 8 on general plan, is a two story structure of brick, with a bell tower, the plan and elevations being given on plate XIII. The first floor plan is arranged with a hall through the centre and a room on each side, one being the master mechanic's office and the other a clerk's office. From the clerk's office a reporting window opens on to the hall, and all the mechanics in the establishment, before going to work, pass through this hall and report their presence to the proper clerk, situated at this window.

The second story is arranged on the same plan as the first, the rooms being used as offices by the car department.

The bell in the tower is of cast steel, 37 inches in diameter (note B) and weighing 836 lbs. It was manufactured by Vickers Sons & Co., limited, Sheffield, England. It is claimed for bells of this material, that they have a very pure, rich and melodious tone, and their sound penetrates to a greater distance than that of any other kind of bell; that they are stronger and more durable than any other, having stood



FRONT ELEVATION. FLANK ELEVATION.

Pennsylvania Railroad Shops,
West Philadelphia.
Office Building.

Scale Feet

Construction Dep.t Penn.a R.R.

the severest frosts without injury, and that for the same diameter and depth of tone they are of less weight than if made of bronze or composition and at the same time of less cost per pound. These bells are in use at four different points on the line of the road, and have, so far, been very satisfactory.

(To be continued.)

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from Vol. LXII. page 404).

The machine, fig. 1, is a direct acting cutting engine for the manufacture of thin boards for bandboxes, or other uses of a similar nature.

The reciprocating carriage shown on the top of the main frame, has a throat similar to an ordinary plane, with an adjustable cutter projecting from its upper face to suit the depth or thickness of the boards to be cut, the face being, of course, adjustable, so that the extreme projection of the edge will be in the plane of table or platen behind the cut. This carriage has a reciprocating motion by means of the winding cord seen in the engraving, which moves it steadily forward, and then allows a quick return for the succeeding stroke.

The block from which the pieces are to be cut is seen on the top of the carriage, where it is held against the face of the knife by means of the abutting brackets, and is forced down by means of the weighted lever shown.

To keep this lever in a horizontal position, as the wood recedes, the fulcrum is so arranged as to move down with the block, actuated by the machine itself.

The speed for ordinary cutting is ten revolutions per minute; weight two and one half tons.

The machine, fig. 2, operates much on the same principle as the one shown in fig. 1. The wood, however, in addition to being cut off in thin boards, is also divided into match splints, at the rate of ten thousand per minute when the whole capacity is employed, or, in other words, when the feeding box is full. The wood blocks are put into the hopper or box seen on top, and, projecting through the bottom, come in contact with the plane or cutter frame, which has a reciprocating motion by means of the crank shaft as shown.

A cut being made and the cutter frame drawn back, the block drops to the extent it has been cut away, ready for the next cut.

The scale is one-twenty-fourths, weight sixteen hundred pounds, speed two hundred revolutions per minute.

Fig. 3 is a true side elevation of a jointing machine for box boards or other short stuff, intended, however, for glue joints of all kinds. To form glue joints by machinery that would be as perfect as those made by hand has been the object of many machines that have failed to accomplish the purpose. The plan here employed, of fastening a number of pieces in an iron carriage moving on strong guides, is no doubt the best that can be adopted to secure true joints.

The lumber, as shown, is set into an iron frame clamped by means of the hand wheel in the front, the lower edge projecting down to meet the cutter shaft; this carriage is traversed by means of the screw and bevel gearing, which can be readily understood from the drawing.

ON THE FLOW OF WATER IN RIVERS AND CANALS.

By J. Farrand Henry, Ph. B.

(Continued from Vol. LXII. page 389.)

Bottom Velocity.

Capt. Boileau says:* "The observations should be continued to a short distance from the bottom, for in that region the velocities decrease rapidly." And again:† "Returning to the observations made by Dubuat upon the movement by translation of grains of sand which follow the bottom of the canal, let us compare these movements with that of the liquid at the same depths. According to that engineer's estimates, the velocity of translation was only about 0·003 of an inch (0·00008 m.) per second in a current where the lower layer of water moved at about one foot (0·325 m. per second, a result which at first appears inexplicable; for, even admitting a notable error in the measurement, these quantities still differ enormously. However, remarking, in the first place, that Dubuat measured the bottom velocities in his experimental canal, by means of small spheres 0·24 inch (0·006 m.) or less in diameter, while the grains of sand were not over one-tenth this size, it seems that the molecules of liquid very near the bottom have a very slight movement, and that in the small inferior zone or layer the velocities increase very rapidly to a certain height, where this increase follows the laws discovered by means of the hydrometrical instruments.

* Mesure des eaux courantes, page 302. † Idem, page 339.

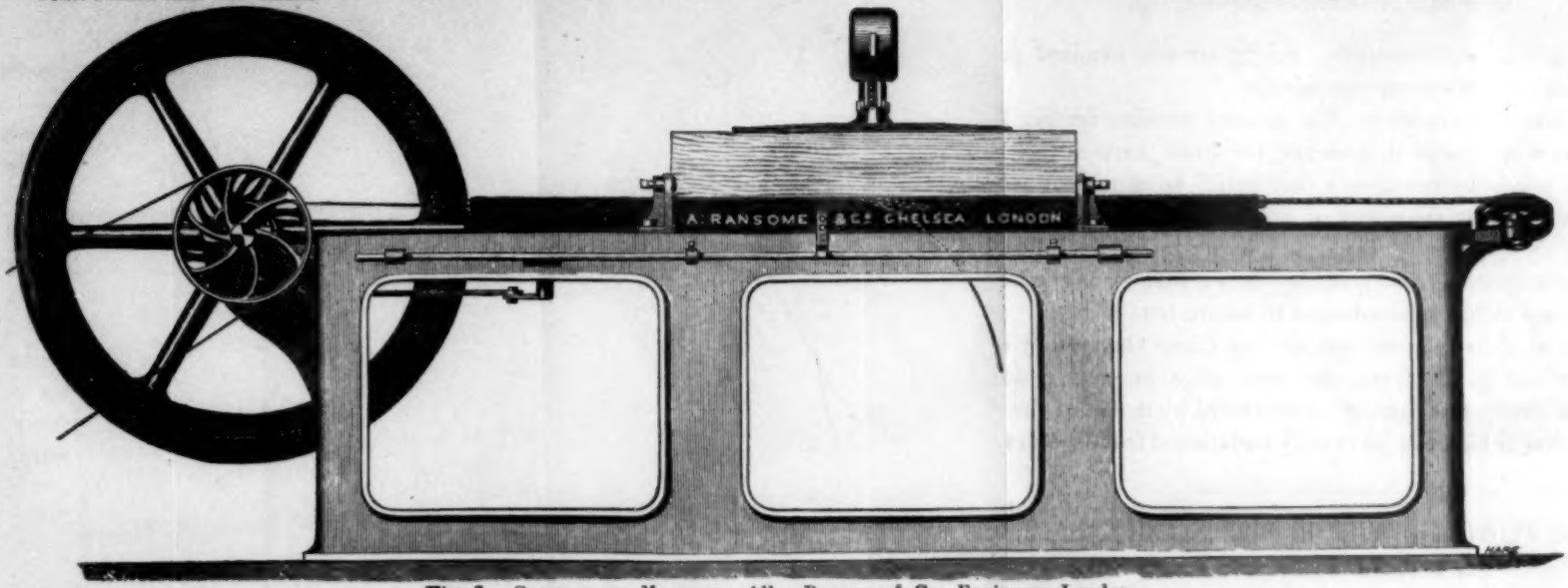


Fig. 1.—Scale-board Machine. Allen Ransome & Co., Engineers, London.

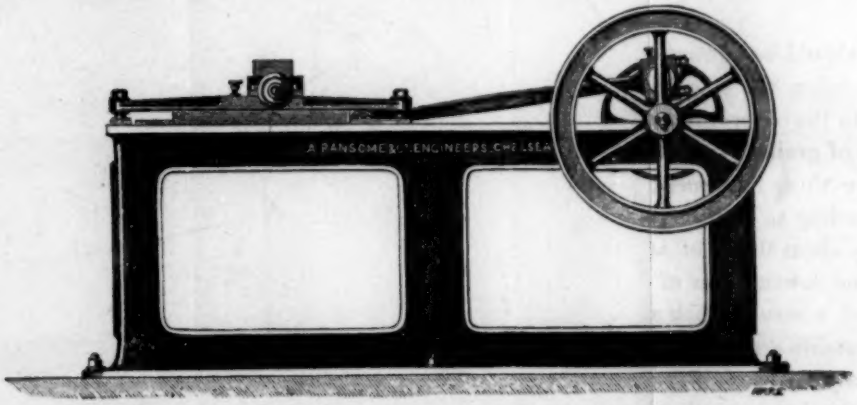


Fig 2.—Match Machine. A. Ransome & Co., Engineers, London.

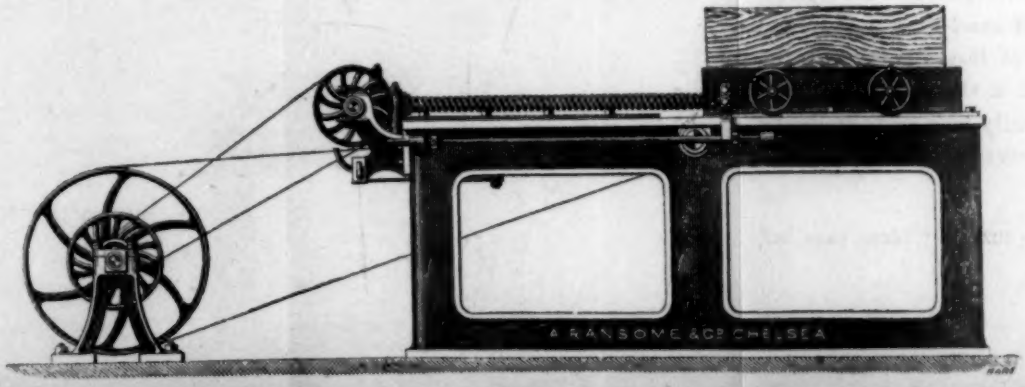


Fig. 3

Fig. 6.

Difference of Floats & Meter

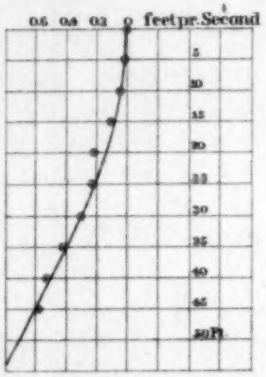


Fig. 6.

Surface & bottom Velocity Curve, NIAGARA RIV.

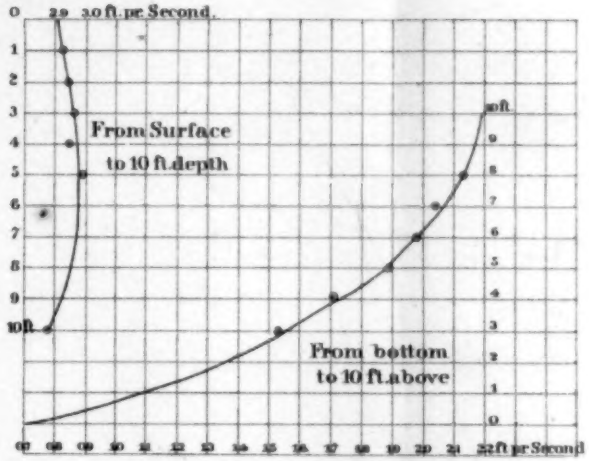


Fig. 10.

Vertical Velocity Cu
NIAGARA RIV

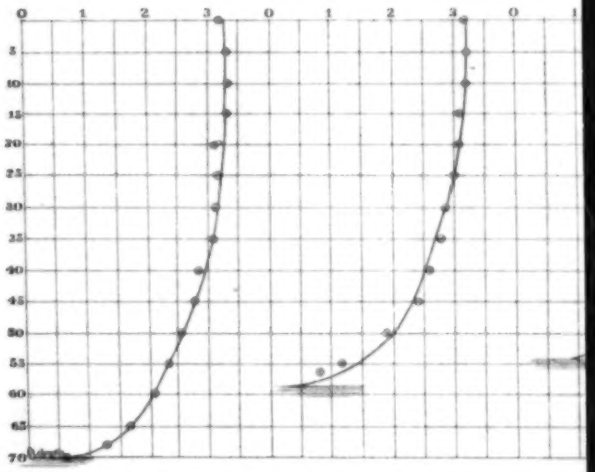


Fig. 7.

Surface & bottom Velocity Curves St Clair River

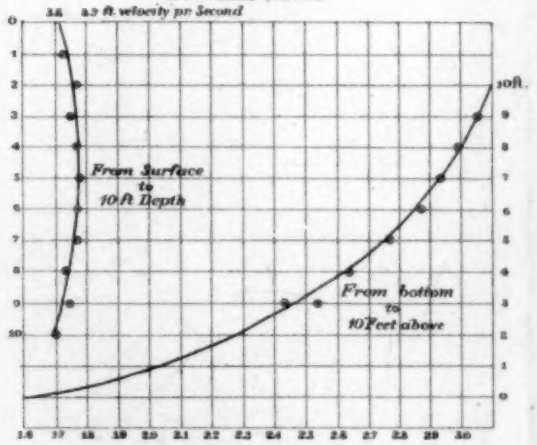
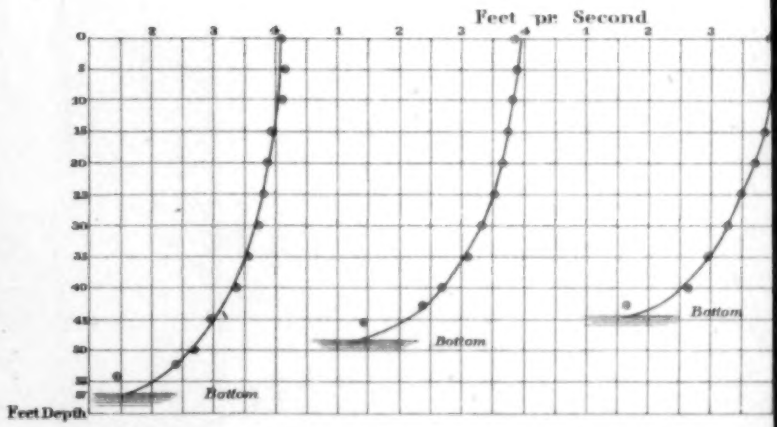


Fig. 9.

Vertical Velocity Curves in St. C



Jas. McGuigan. Lith.

Fig. 10.

Vertical Velocity Curves
NIAGARA RIV.

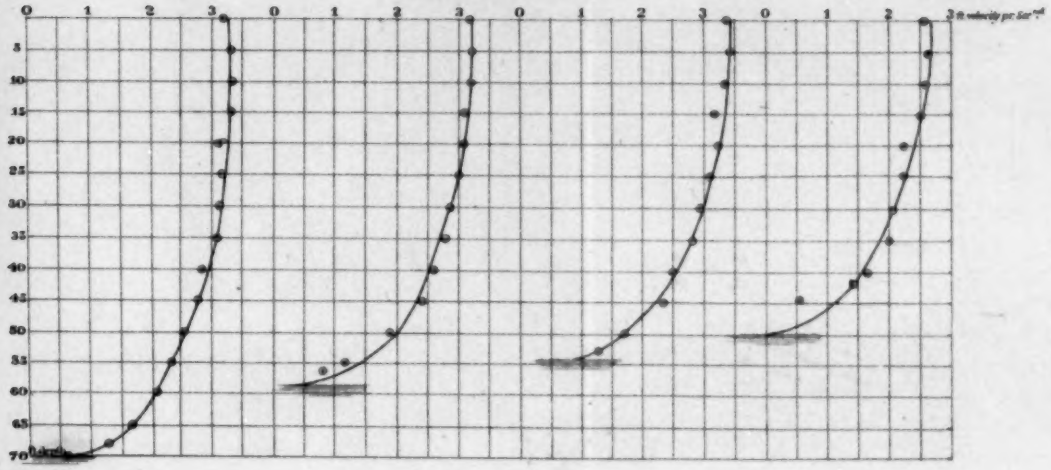


Fig. 9.

Vertical Velocity Curves in St. Clair Riv.

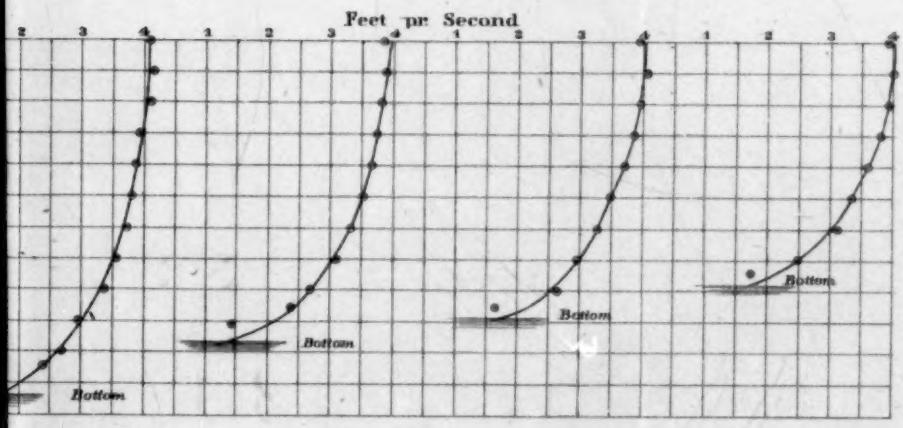


Fig. 12.

Horizontal Velocity Curves in St. Clair River

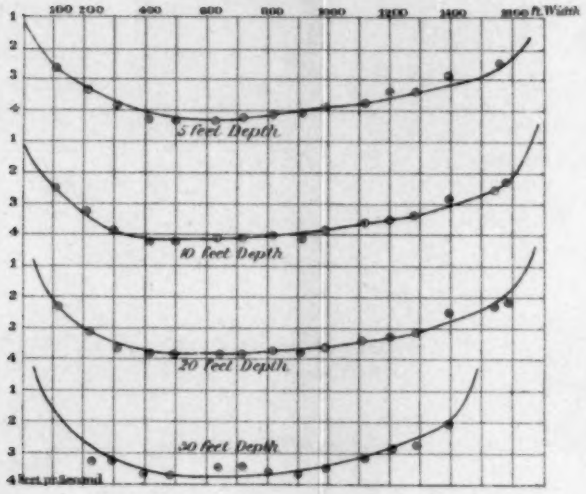


Fig. 13

Capt BOILEAU's observations in small Canal at Metz

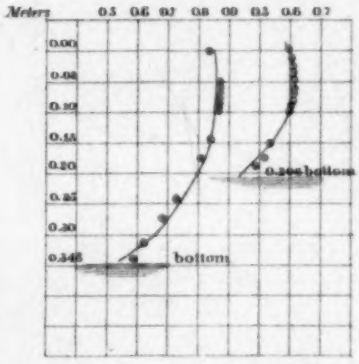


Fig. 11

Vertical Velocity Curves St. Lawrence

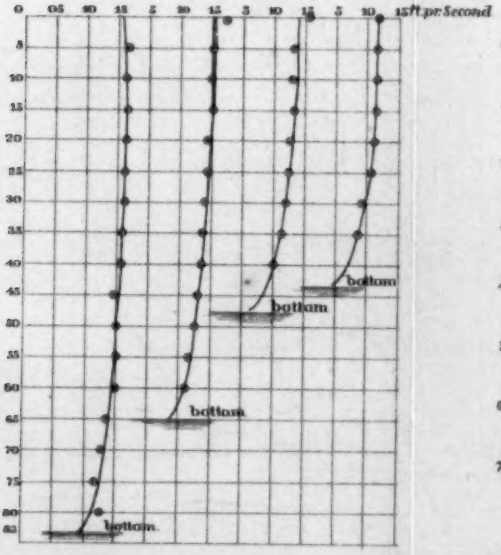
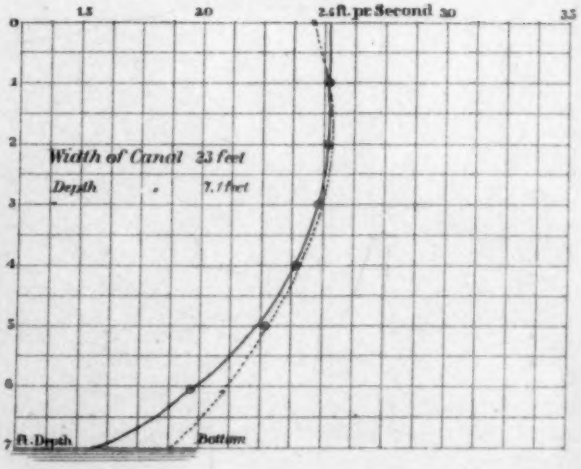


Fig. 14.

Vertical Velocity Curve of Feeder of O. & C. Canal obtained by Floats HUMPHREY & ABBOT



"This circumstance seems to confirm the opinion of Dubuat and the greater part of hydraulic engineers, who hold that the fluid molecules in immediate contact with the bottom of the canals are made immovable by their adherence." Then follow his remarks (already quoted*) on the formation of eddies.

To obtain actual measurements of the bottom velocity seems almost impossible.

In small canals the distance between the lowest measurement and the bottom affords ample space for great changes in the velocity, as Dubuat's experiments show; and in deep rivers it is difficult to get a meter close to the bottom, or rather to know exactly how near the bottom it is; and, as the pulsations of the current are so great in that region, the velocity will sometimes be so slow that the meter will stop for a time, and thus make the mean too large. Floats, as we have seen, are entirely unreliable for such observations, for the exact depth of the lower float can never be known, and they invariably give too high velocities.

Notwithstanding the experiments noted above, Dubuat gives a formula for the bottom velocity which makes it a little more than half that at the surface. He considered also that the bottom velocity was the same for like surface velocities, whatever the depth of the stream, and that it was not affected by the nature of the bed.

Darcy and Bazin have shown that the nature of the bed materially affects the velocity, a different constant being used in their formula for beds of plank, masonry, cement, earth, &c., and the later observations seem to show that the bottom velocity changes with the depth also.

The bottom velocities given by Dubuat's and other formulæ, and found in all hydraulic tables, can only be considered as the lowest measured velocity. Dubuat, Blackwell and others have measured the velocity of currents capable of moving different substances, which may be condensed as follows:

16 feet a minute will start white clay.
40 " " " move along coarse sand.
60 " " " " fine gravel.
120 " " " " rounded pebbles 1 inch in diameter.
200 " " " " flint stones size of hens' eggs.

Beardman's tables, which are computed by Dubuat's formula, give a bottom velocity of 2·92 feet per second for a surface velocity of four feet per second, or about three miles an hour. This, according

*Ante, page.

to the above table, would move along pebbles over an inch in diameter; while we know from experience that rivers of a much greater surface velocity run over beds composed of soft sand or finely comminuted clay, with but little change in their cross section, through quite long periods of time. In a small clear stream, I have watched the gathering of small particles of vegetable or earthy matter, whose specific gravity was so nearly that of the water that they would just sink upon the small stones at the bottom, but if they were disturbed so as to rise out of the lower layers of water, they would be immediately carried off by the current.

At times, of course, when the conditions are favorable, the scouring of rivers is very great, but ordinarily they appear to have but little action on the bed.

In the report of Mr. Chas. Ellet, Jr., on the "Inundations of the Mississippi," is the following:* "To excavate a channel through soil of a given texture, and to keep the same channel open when so excavated, are two very distinct things, requiring very different applications of force. We find, consequently, that it is no easy thing, even with a great fall and a great volume, to open a new channel by the mere action of the running water of the Mississippi. The first attempt to make a cut off at Racourci, where the fall was at the rate of six feet to the mile, were unsuccessful, although a considerable volume of water was let through an artificial trench leading from the river above to the river below the bend. Various other attempts to create cut-offs across bends in the upper portions of the river have likewise been unsuccessful, although sometimes aided by a descent of 7 or 8 feet per mile.

"The Atchafalaya and the Plaquemine have probably been open for ages—certainly from periods far beyond the reach of history or tradition—the first having a fall more than twice as great, and the other a fall *ten times as great* as the Mississippi itself; and yet, unaided by art, they have been found unequal to the task of increasing the depth of their channels, or enlarging their respective waterways. On the contrary, the Atchafalaya, in the view of the writer, seems to have been contracting its original width for a great many years.

"The crevasse at Bonnet Carré discharged into Lake Ponchartrain about the one-tenth part of the high-water burden of the Mississippi, for many consecutive days, during the great flood of 1850, when the water of overflow rushed down a plane descending about fifteen feet

* Ex. Doc., 20, 1852, page 67.

in 4½ miles; and yet the velocity and force of the torrent were not sufficient to tear up the natural soil to any considerable extent. No channel was excavated. The furrows left by the plow and the roots of the crop remained on the field where it had been swept by the water, after the flood had subsided."

There were also two attempts to make artificial cut-offs during the Rebellion, which were unsuccessful.

A curious story was told by the divers employed in the construction of the St. Louis bridge across the Mississippi. It must be taken for what it is worth; yet it seems hardly possible that it could have been an invention of their own:

During the sinking of those piers, large scows were moored alongside; and the divers reported that the bottom of the river underneath the scows was scooped out just about the amount they extended beneath the surface. This would seem to show that while the river was in its normal condition—the discharge and cross section being in equilibrium—the sand and silt of the bottom was undisturbed; but an obstruction being placed in the stream which reduced the cross section, the velocity at the bottom was increased till the equilibrium was restored.

If an obstruction be placed in the bottom of a river, thus lessening the cross-section, the surface level will be raised; and if an obstruction be placed near the surface, it would seem as if the bottom or sides must yield.

These are, of course, only conjectures, but they all seem to indicate that the real bottom velocity in rivers must be very small.

In the Mississippi observations, the bottom velocity exceeds that of the surface in 28 out of the 69 selected verticals, in some cases being more than one foot a second in excess, and in one vertical, as has been already mentioned, the *maximum* velocity is recorded at one foot *below the bottom.*

It was found impossible to obtain satisfactory results in the rivers connecting the lakes below about three feet from the bottom, both from the uncertainty of position, and the intermittent velocity, as before noticed.

The means of the measurements from that depth to ten feet from the bottom are given in Table X, and are also plotted in figures 7 and 8, being represented by the circumscribed dots.

A free hand curve, shown by the full line, is drawn through as many of these points as possible, and continued till it meets the bottom; the ordinates of this curve being also given in the table:

TABLE X.

Distance from the Bottom.	St. Clair's River.		Niagara River.	
	Observed Velocities	Ordinates of Curve.	Observed Velocities.	Ordinates of Curve.
10	3·053			
9	2·988	0·060		0·040
8	2·935	0·115	2·124	0·095
7	2·870	0·180	2 034	0·175
6	2·782	0·250	1·975	0·260
5	2·734	0 330	1·889	0 360
4	2·624	0·440	1·710	0·495
3	2·437	0·590	1·536	0·660
2		0·790		0·870
1		1·050		1·120
Bottom.....		1·550		1·500
No. of Verticals	33		20	

These curves show a very rapid decrease in the velocity towards the bottom, and thus agree with Dubuat's experiments on the translation of grains of sand; but the bottom velocities are still very large compared with the slow motion of those particles, being nearly a foot and a half a second in the St. Clair and seven-tenths of a foot in the Niagara.

According to the table on page , the former velocity ought to carry along coarse gravel; yet, while the bed of the St. Clair is composed of clay so soft that a sounding lead sinks into it a foot or more, the form of the bed has not changed materially in the past ten years.

The mean surface velocities corresponding to these bottom velocities are, in the St. Clair, 3·6 feet per second, and 2·9 in the Niagara.

The depth of the former river is over fifty feet, and of the latter about 70 feet.

This shows, as far as a single case can, that the bottom velocity is dependent on the depth as well as on the surface velocity, and the character of the bed; which seems much more rational than that it should be a function of the surface velocity alone.

In an article in "Nature," by Mr. S. Login, upon the abrading and transporting power of water, the following "Practical Conclusions" are arrived at:

"1st. That all particles of water have an affinity to each other, as to other bodies, and that force is required to separate them.

"2d. That friction sets these particles rotating in all directions, in larger or smaller circles, and that the friction or force increases in some proportion to the area of surface exposed.

"3d. That this rolling motion becomes rarer the larger the diameter of the circles may be; that is, the resistance decreases as the depth and breadth of the stream increase; or, in other words, the velocity increases proportionally to the 'hydraulic mean depth.'

"4th. Lastly, that any increase to the rapidity of this rotatory motion must increase the abrading and transporting power of water, by enabling it to remove from the channel of a stream grains of solid matter, and hold them in suspension."

And he quotes from a series of papers in "The Artisan," the following "Supposed Law:"

"The abrading and transporting power of water increases in some proportion as the velocity increases, but decreases as the depth increases."

This idea of the rolling motion of water caused by friction is the same as that of Captain Boileau of the eddies, which he thought were generated by the adhesion of the water to the bottom of the stream; and if, as seems to be true, the resistance, and therefore the abrading power of water decreases as the depth increases, the bottom velocity must also decrease even should the surface velocity be the same.

Form of Velocity Curves.

Almost every writer on the subject of hydraulics adopts a new form of velocity curve.

Woltmann found that a reversed parabola, with its vertex below the bottom of the river, agreed best with his observations on the Rhine.

Defontaine, also on the Rhine, found the greatest velocity at the surface; that it decreased slowly at first, and then more rapidly towards the bottom, and he considered that this decrease approximated to two right lines of different inclinations, intersecting at a point probably below mid-depth.

Racourt, in his current measurements on the Neva, found the decrease in the vertical velocity was best expressed by an ellipse whose minor axis was a little below the surface. He also found that the same curve would agree closely with the increase of the velocities in a horizontal plane from the banks to the center of the stream.

Funk adopted a logarithmic curve in his observations on the Weser.

Boileau found a parabola, with its axis at the surface, agreed best with his observations on experimental canals.

Darcy and Bazin found the reversed parabola approximated most closely to the velocities they obtained, but the parameter changed with the character of the bed.

Humphreys and Abbot, in the Mississippi observations, adopted a parabola with its axis three-tenths of the depth below the surface.

M. Baumgarten says: "In constructing the curve of different velocities corresponding to each point of vertical height of a sounding, we can assure ourselves that the engineers who have maintained that the curves were ellipses, or right lines with a slight inclination to each other, might all have been more or less nearly right (pouvaient tous avoir plus ou moins raison), according to their observations; but I believe that in reality no simple curve gives a rigorous expression of the truth, and that they are all merely approximations, even as ellipses are but approximations to the orbits really described by the planets."*

In the survey for the outflow of the lakes the method adopted for obtaining the vertical curve of velocity was to combine all the observations or verticals whose depth did not differ more than three feet.

Four of these combined verticals for each of the rivers of St. Clair, Niagara and St. Lawrence are given in Table XI.

The velocities are a mean of all the observations at the places and depths noted.

In the St. Clair and Niagara the surface and bottom velocities are taken from the curves given in Tables IX and X.

As these curves are not applicable to the St. Lawrence river, those velocities are omitted.

TABLE XI.

ST. CLAIR RIVER.				
Depth.	54·6 feet.	45·4 feet.	42·5 feet.	37·0 feet.
	4·034	3·868	3·958	3·409
5 ft.	4·109	3·907	4·013	3·484
10	4·043	3·821	3·900	3·379
15	3·958	3·709	3·798	3·223
20	3·887	3·608	3·663	3·050
25	3·778	3·496	3·501	2·784
30	3·624	3·309	3·228	2·529
35	3·503	3·100	2·904	2·379
40	3·323	2·678	2·600	1·159
45	2·986	1·428	1·250	
50	2·650			
55	1·472			
No. of Verticals	11	32	18	14

* Annales des Ponts et Chausses, tome xx, 1847, page 362.

TABLE XI—*Continued.*

NIAGARA RIVER.				
Depth.	69·9 feet.	56·1 feet.	53·2 feet.	44·1 feet.
	3 169	3·125	3·376	2·577
5 ft.	3 239	3·195	3·446	2·647
10	3·279	3·184	3·347	2·601
15	3·261	3 081	3·171	2·499
20	3·154	3 085	3·209	2·291
25	3·124	2·858	3·108	2 225
30	3·083	2 815	2·957	2·153
35	3·037	2·765	2·809	1·996
40	2·842	2·594	2·499	1·670
45	2·760	2·371	2·321	0·652
50	2·651	1·877	1·766	
55	2·333	1·252	0·931	
60	2·014	0·807		
65	1·654			
70	0·552			
No. of Verticals	8	15	31	10

TABLE XI—*Continued.*

ST. LAWRENCE RIVER.				
Depth.	83·0 feet.	65.2 feet.	46.1 feet.	42·5 feet.
5 ft.	1·638	1·533	1·332	1·176
10	1 609	1·509	1·320	1·194
15	1·596	1·507	1·369	1·143
20	1·602	1·470	1·292	1·075
25	1·569	1·477	1 280	1·065
30	1·549	1·417	1·214	0·969
35	1·576	1·398	1·153	0·874
40	1·521	1·357	1·007	
45	1·486	1·315		
50	1 483	1·236		
55	1·500	1·167		
60	1·504	1·092		
65	1 385			
70	1·289			
75	1 180			
80	1·202			
85				
No. of Verticals	4	66	14	5

These velocities are plotted in figures 9, 10 and 11, being represented by the circumscribed dots.

In the deeper verticals, the velocities near the surface plot nearly

in a perpendicular line, while in those of less depth the velocities incline more from the surface. It was found that an ellipse whose minor axis was at or near the surface, with the vertex a little below the deepest vertical, would pass through nearly all the plotted points of that vertical, and by raising the minor axis above the surface would also pass through the plotted points of the other verticals at the same station, except in those very near the banks, the velocities there decreasing too rapidly from the surface. This ellipse is shown by the full line in the figures, being the same curve for the St. Clair and Niagara, but more eccentric for the slow and deep current of the St. Lawrence.

In figure 12 the velocities across the river St. Clair, at different depths, are plotted. These were obtained by taking the mean of all the observations every fifty feet across the river at the several depths.

As these measurements were made on different days, the means would not probably show as regular a curve as the verticals, where one or more series were taken during the same day.

They are given only to show that the same form of curve satisfies the velocities in a horizontal as well as in a vertical plane, the full lines representing two semi-ellipses meeting in the "Thalweg," or deepest part of the river.

As we have seen, the curve adopted in the Mississippi observations was a parabola with its axis three-tenths the depth below the surface.

To compare the observations on these rivers with this curve, two verticals were selected, one in the St. Clair and one in the St. Lawrence. These verticals were chosen, partly because they were the mean of the largest number of observations, and partly because, not being the deepest verticals in the rivers, the velocities were not so nearly equal near the surface, and therefore would compare more favorably with the parabola. Also, instead of taking the axis at three-tenths the depth, it was assumed at five feet from the surface, or one-ninth the depth in the first vertical, and one-thirteenth in the second.

(To be continued.)

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from Vol. LXII, page 391.)

"In the present experimental state of the introduction of pulleys and belts, moving with high velocities for the transmission of power

to a distance from motors, a few facts may be briefly stated to inspire confidence in the operators of mills to adopt new arrangements by learning what has been found practically successful.

"A good leather belt, one inch wide, has sufficient strength to lift 1000 lbs.

"The speed of a mile per minute for main driving leather belts has been found both safe and advantageous for practical use.

"The capability of belts to transmit power is determined by the extent of its adhesion to the surface of pulleys.

"The extent of adhesion of belts varies greatly under varying circumstances of the use of them, and is very limited in comparison with the absolute strength of the leather.

"The adhesion and friction, causing the belt to cling to the surface of a pulley without slipping, is mainly governed by the weight of the leather,—if used horizontally.

"If belts are strained tightly on the pulleys, then the adhesion is increased in proportion to the increased tension produced.

"The weight of leather in vertical belts tends to produce a sag beneath the under side of the under pulley; and, if loosely put on, might not touch it at all, to tranmit power by adhesion. For this reason it is necessary to strain on more tightly all vertical belts, with a dependence on the elastic stretch of the leather for producing adhesion.

"A vertical belt of single leather of the width of six inches, and with a velocity of 5200 feet per minute, has practically been used very satisfactorily at the Georgia mill, during several years, to operate 10,400 self-acting mule-spindles, and the spoolers and warpers for the same; and another belt of similar width and velocity, 110 feet in length, has served to transmit the power from a 24-feet waterwheel, 18 feet long, under a fall of 20 feet, with the same velocity of 5200 feet.

"A 24-inch belt of single leather, with the velocity of 4850 feet per minute, has transmitted all the power of a steam engine of six-feet stroke, thirty-inch cylinder, making forty revolutions per minute, and with so slack a tension on the returning side as to flap and wave with an undulating movement.

"These statements are specified simply to show what has been done by belts running with certain velocities,—not for the purpose of holding them up as models for imitation.

"No fixed rule can be gived for calculating the actual adhesion of belts; for this adhesion depends upon so many contingent facts of their relative positions and weights, as affected by greater or less lengths and breadths, and lightness. As the result of experimental observations, it may safely be calculated that, with a properly slack belt, the effective adhesion of a horizontal belt may be taken at 30 lbs. to each inch of width of short belts, and double of this on long belts, with threefold or more if tightly strained on the pulleys, which never should be done; for this increases the friction of the bearings and waste of power, in addition to injuring the durability of the leather for service.

"Clamps with powerful screws are often used to put on belts with extreme tightness upon the pulleys, and with most injurious strain upon the leather. They should be very judiciously used for horizontal belts, which should be allowed sufficient slackness to move with a loose undulating vibration on the returning side, as a test that they have no more strain imposed than what is necessary simply to transmit the power.

"Rather than to continue to use horizontal belts with overstrained tightness to obtain the necessary adhesion, it is often better to use larger pulleys, which require less adhesion to transmit an equal extent of power.

"On the scientific principle that the adhesion, and consequently the capability, of leather belts to transmit power from motors to machines is in proportion to the pressure of the actual weight of the leather on the surface of the pulley, it is manifest that, as longer belts have more weight than shorter ones, and that broader belts of the same length have more weight than narrower ones, it may be adopted as a rule that the adhesion and capability of belts to transmit power is in the ratio of their relative lengths and breadths. A belt of double the length or breadth of another, under the same circumstances will be found capable of transmitting double the power. For this reason it is desirable to use long belts. By doubling the velocity of the same belt its effectual capability for transmitting power is also doubled."—*Z. Allen, Esq., Providence, R. I., in Proceedings of N. E. Cotton Mfrs.' Ass., No.* 10.

ON THE EXPLOSION OF STEAM BOILERS.

By Wm. M. Henderson, Hydraulic Engineer.

In response to an invitation received from Mr. Francis B. Stevens, Engineer of the United Railroad Companies of New Jersey, to witness a continuation of the experiments relating to the causes of steam boiler explosions, the Franklin Institute sent a committee, Nov. 22d, to the United States reservation at Sandy Hook, composed of the following members: Messrs. Coleman Sellers, President; W. H. Wahl, Secretary; Jacob Naylor and W. M. Henderson, Mechanical Engineers.

Upon arrival at the destination there were found nine steam boilers, within a board-fence enclosure, each set up with smoke stack complete, and fired up, ready for the test of their endurance.

The circular which is here appended will suffice to furnish all the data for a proper understanding of the results of the trials:

Office of the Camden and Amboy Shops,
Foot of Second Street,
Hoboken, New Jersey, Nov. 22d, 1871.

To the gentlemen invited to be present at the experiments made by the United Companies of New Jersey, on Wednesday, Nov. 23d, 1871, at Sandy Hook:

On the 11th of September last, the Executive Committee of the Companies passed the following resolutions:

"That, in order to attain greater safety in the steam boilers belonging to the United Companies, Mr. F. B. Stevens be authorized to continue the experiments on the strength and proper management of such boilers and for this purpose to expend not exceeding ten thousand dollars, the vouchers for which to take the ordinary course.

"That other owners of steam boilers are hereby invited to contribute to the experiments to be made by Mr. Stevens; and that the wharf. shops, derrick, or tools belonging to the United Companies at Hoboken may be used for this purpose, at cost prices, and a copy of the charges given by the Auditor to the contributors.

"That Mr. Stevens be advised to invite the United States Inspectors, and other prominent engineers, to be present at the experiments."

And on the 20th of the same month I received permission from the Secretary of War, at the instance of the President, to make the experiments on the Government reservation at Sandy Hook.

The boilers to be experimented on are nine in number, and each boiler has its number painted on it in large figures. Nos. 1, 2, 3 and 4 are the four steamboat boilers that were burst by hydrostatic pressure, at Hoboken, on September 2d, an account of which was widely published in the daily papers. The injury done was so small that they have since been repaired, at an average cost of less than $100 for each boiler.

No. 1 and No. 2 are a pair; they were built by Fletcher, Harrison & Co. in 1858, and were taken out of the boat last July, after having been in use 13

years. They are the ordinary return-flue boilers, identical in shape and general construction with the Westfield's boiler, but smaller. They are 28 feet long, and the shell is 6 feet 6 inches in diameter. They were tested by hydrostatic pressure, in their present position, at Sandy Hook, to 82 lbs., without fracture, on the 4th of November, and on the 15th of November they were subjected to steam pressure—No. 1 to 25 lbs. and No. 2 to 60 lbs. per square inch, without fracture.

No. 3 was built by T. F. Secor, in 1845; was taken out of the boat in August last, after having been in use 25 years. When taken out, the certificate allowed 30l bs. per square inch. It is a return tubular boiler, with the furnace the whole width. It is 12 feet wide by 15 feet 5 inches long.

The crown of the furnace is flat, and braced to the shell by crow feet braces. On September the 2d twelve of the crow-feet gave way under a hydrostatic pressure of 60 lbs. After being repaired it was subjected to a hydrostatic pressure—in its present position at Sandy Hook, on November 4th—of 59 lbs. per square inch, without fracture; and on November 16th it was subjected to a steam pressure of 45 lbs. per square inch, without fracture.

No. 4 was built by H. R. Dunham & Co., in 1849. It was taken out of the boat in July last, after having been in use 21 years. When taken out the certificate allowed 40 lbs. per square inch. It is a return tubular boiler, the same as No. 3, but with a centre leg. It was subjected to a steam pressure of 62 lbs. without fracture.

No. 5 is a cylindrical boiler, without flues built for these experiments. It is 80 inches in diameter and 10 feet long, the heads being flat. The iron is all $\frac{5}{16}$ inch thick; part of the shell is made of Pennock's best flange iron, and part of Pennock's Eureka, as painted on the boiler. One head is made of Pennock's Eureka iron, and the other head of the Abbott Iron Company's best flange fire box. The heads are braced by rods of best imported Norway iron, $\frac{3}{4}$ inch in diameter and 10 feet long, and spaced in squares 6 inches apart, over the whole surface of the heads. These braces are screwed into each head, and also have a nut on the outside of each head. The longitudinal seams are double riveted. The object here has been to construct a boiler of nearly uniform strength throughout. Flat heads, braced across from head to head, were adopted instead of hemispherical ends, to prevent the rivets of the shell from being subjected to a cross strain. The boiler was tested by hydrostatic pressure to 172 pounds, without fracture, and it has been tested by steam up to 75 pounds, in its present position.

No. 6 is a flat surface, 6 feet long, 4 feet high and 4 inches wide, built for these experiments, and copied after the back end of the Westfield's boiler. It is made of the Abbott Iron Company's best flange fire box. The plates are the same thickness as the Westfield's, viz., $\frac{5}{16}$ thick, and the stays connecting these plates are the same diameter as the Westfield's, viz., $1\frac{1}{8}$, with the same sized thread, and they are spaced in the same manner and at the same distance apart that the Westfield's are. Care has been taken to make the riveted heads of these braces as nearly as possible like those of the Westfield's. This piece of a boiler has been subjected to a hydrostatic test of 138 lbs. per square inch, without fracture, and to a steam pressure of 102 lbs. per square inch, in its present position at Sandy Hook.

Nos. 7 and 8 are small upright boilers, nearly new and very strong, being two feet in diameter, and built of iron ¼ of an inch thick. They have been subjected to a hydrostatic pressure of 180 lbs., without fracture. No. 9 is a cylindrical return tubular boiler, 42 inches in diameter and 8 feet long, and it has been subjected to a hydrostatic pressure of 180 lbs., without fracture.

The four steamboat boilers have been repeatedly burst by hydrostatic pressure, and repaired; and they are undoubtedly able now to bear a much greater pressure without fracture than they were when taken out of the boats. But the question is, have they been overstrained? for the object has been to ascertain to what extent boilers of the form tried are overstrained when the margin for safety between the test pressure and the pressure allowed is two to one.

The intention is to try all these boilers with the safety-valves fastened down or removed, so as to allow the steam gradually to increase until a rupture takes place. On the four steamboat boilers the intention is to ascertain and compare the difference in the ruptures that were produced by hydrostatic pressure with those produced by steam gradually accumulated, and also to ascertain and compare the differences of the ruptures produced by steam gradually accumulated with those produced in experiments to be tried at a future day with the water low. On No. 5 the intention is to try what effect the gradual accumulation of steam to the point of rupture has on the rivets and seams of a new boiler, made nearly equal in strength throughout. On No. 6 the intention is to endeavor to approximate to the pressure per square inch required to tear the back of the Westfield's boiler from the stay-bolts. On Nos. 7, 8 and 9 the intention is to endeavor to corroborate the experiments on No. 5.

The boiler of the Westfield has been purchased from Mr. John Roach, who with liberality and forethought saved it from being cut up. If the experiments are continued, it is proposed to repair the Westfield's boiler, and then to endeavor to ascertain by trial the pressure at the instant of explosion, and also to ascertain whether the explosion was produced by a pressure gradually accumulated, or by one suddenly produced. The question as regards the Westfield is a simple one. Was the disaster caused by want of strength in the boiler? or was it caused by so sudden an accumulation of pressure, produced by low water, that an increase of the strength of the boiler would have only added to the disaster? On this point engineers differ; but, taking the fact into consideration that nearly all the ferry-boats in the harbor of New York have boilers identical with the Westfield's, the question should be settled so that not the shadow of a doubt should remain.

FRANCIS B. STEVENS.

Outside the enclosure were two large fresh-water tanks, for supplying the boilers with water. A number of steam gauges were also arranged upon one side of the fence, the highest graduated to indicate 500 lbs. to the square inch. As it would have been impracticable, however, to refer to these upon the final bursting of each boiler, there were erected, at a distance of 250 feet, two other gauges, one indicating to 100, the other 500 lbs. per square inch, the latter being a mercury gauge. At this stand all retreated to witness the expected explosions.

The experiments commenced with boiler No. 2. The fuel used was wood, and a quantity was packed in the furnaces, of which there were two, sufficient it was considered to generate steam enough to cause explosion, there being no safety valve or any possible avenue of escape for the steam, except through the sheets composing the boiler. The pressure slowly gained until there was indicated upon the gauges situated at the safe point of observation a pressure of about 65 lbs., at which time small wreaths of steam could be observed escaping from the seams. This was followed by a quantity seen to escape from the smoke stack, indicating a leak, probably, in the furnaces. As the pressure rose the escape of steam from the seams increased, until a pressure of 92 lbs. was reached, when the volume discharged became greatly increased, and could be heard quite audibly at the indicator stand. The pressure went up to 93 lbs., but here the leak was so great, it became apparent the fire had gained its maximum and a vent had been created sufficiently large to carry off the steam as promptly as it was generated. From this point the indicators of the gauges began a retrograde movement, and after a lapse of about 20 minutes the boiler was approached and the fires smothered with sand—a wise precaution, as an attempt to draw the fires might have accelerated the generation of steam with disastrous effect. The appearance then presented by the boiler was probably more instructive and of far greater significance to the professional engineer than if an explosion had actually taken place. Here was a boiler on the very verge of destruction, saved almost by a miracle, to illustrate the manner in which some boilers take the initiative step to explosion.

This boiler was of the return-flue description, the smoke-stack passing through the steam-drum. Looking at the point of leak, which was at the rear of the steam-drum, where it joins the shell, it was discovered that the shell at this point had been visibly drawn downwards. This naturally drew attention to the furnaces, and, as might be reasonably inferred, both crown sheets, originally flat and stayed to the roof of the outside shell, had been forced down and bulged in the center of each, between two rows of the stays referred to, to an extent of about two inches, pulling the outside shell with it, as represented, away from the lower sheet of the vertical steam-drum, thus opening a seam, venting the boiler, and alone saving it from destruction. Had the boiler exploded, the starting-point would have been a matter of conjecture. Here we have it to a certainty. A little more pressure would have completed the destruction of this boiler, each fragment of

which more than likely would have found an advocate ready to prove it to be the incipient cause of the catastrophe. The giving way at this point was no doubt caused by the shell being there weakened by the large amount of metal cut out to accommodate the steam-drum, and would suggest the addition of a stiffening ring at such locations. It cannot be denied, however, but that the boiler was well proportioned in all its parts, and showed an admirable power of endurance.

The second experiment was made with water-leg No. 6. The fuel used and manner of conducting this experiment was the same as pursued in the case of No. 2. The structure was placed, edgewise, between two brick furnaces, and flanked by a brick wall on each side. The pressure, as indicated by the gauges, rose quite rapidly after the steam began to form, increasing from 44 lbs. to 100 lbs in ten minutes, and subsequently at the rate of about 10 lbs. per minute. In seven minutes more the pressure had accumulated to 165, at which point explosion took place, with a loud report, the sides parting right and left, the former being projected through and carrying away part of the wooden fence, and lodging in the sand distant about 125 feet. The latter half caused more mischief, in its career striking the fire-box of boiler No. 3, knocking a large hole in it, and liberating its steam, preventing that boiler from being subjected to further experiment for the time being. The brick furnaces and walls were utterly demolished, and many of the bricks were hurled with fearful violence to within a few feet of where the spectators stood by the indicator gauges.

Upon an examination of the sheets they were found to be much bellied and contorted. The wrought-iron frame through which the rivets passed, binding the edges, was found to have been made in four pieces, mitred at the corners, the joints having been made with great care. This proved to be a very bad arrangement, for some of the corners of the sheets, which should have been the strongest parts, were ripped diagonally towards the centre, plainly showing all such distance pieces should be *welded.* The direct cause of this explosion was very apparent and readily traced to the general insufficiency of the riveting. The rivets were placed two inches apart, the heads being merely turned over. The same was the case with the stays. These were $1\frac{1}{8}$ inch in diameter, placed about $8\frac{1}{2}$ inches apart. Parts of the plates were torn through the line of rivets; but the great fault existed in the poor specimen of boiler workmanship. It seemed so eminently absurd to select stays so large as $1\frac{1}{8}$ inch, and then merely

insert them through the two sheets, with no more hold than the little afforded by the amount of screw thread to be obtained in boiler plates of but $\frac{5}{16}$ inch thickness, the riveting amounting to almost nothing. A section such as this secured by socket bolts, riveted hot, or by screw nuts, would have withstood a pressure of 400 lbs. to the square inch. As it was, this badly constructed part was as strong as the rest of the boiler, and it only proves that flat surfaces, properly stayed, are the strongest parts of our steam boilers.

In connection with these experiments there was made manifest a very beautiful illustration of the directions taken by the strains upon the sheets. It was observed there were lines proceeding from one stay to the other, by a system of mathematical convolute curves spaced about one-sixteenth of an inch apart in the widest range. As these crossed each other, diverging from one stay to another, the effect was very beautiful, resembling in form the rays thrown off by the pyrotechnic pin-wheel, so familiar to our readers. This appears to present a new field for scientific discussion, and may lead to important results, if the phenomenon can be successfully accounted for. We hope some of our scientific readers may be enabled to throw some further light upon this truly remarkable subject.

[In continuation of the same subject, the following circular letter, addressed to the Hon. Secretary of the Navy by the Chief Engineers, whose names are attached, contains a confirmation of the preceding, as well as much additional information of interest to engineers. A memorial, signed by the most prominent scientific names throughout the country, will shortly be presented to Congress, with the object of securing Government aid for a thorough investigation of this all-important subject:—Ed.]

New York, December 12th, 1871.

Sir,—Agreeably to your orders of the 18th ultimo, appointing the undersigned a Board to witness, report upon, and give all necessary information relating to the experiments being made at Sandy Hook, New York, by Mr. Francis B. Stevens, of Hoboken, New Jersey, on steam boiler explosions, we have the honor to submit a description of them as far as they have progressed, accompanied by our observations on their results.

The experiments referred to were devised by Mr. Stevens, in pursuance of the following resolutions, passed on the 11th of September last by the Executive Committee of the United Railroad Companies of New Jersey, namely:

"That, in order to attain greater safety in the steam boilers belonging to the United Companies, Mr. F. B. Stevens be authorized to continue the experiments on the strength and proper management of such boilers, and for this purpose to expend not exceeding ten thousand dollars, the vouchers for which to take the ordinary course.

"That other owners of steam boilers are hereby invited to contribute to the experiments to be made by Mr. Stevens; and that the wharf, shops, derrick and tools belonging to the United Companies at Hoboken may be used for this purpose, at cost prices, and a copy of the charges given by the Auditor to the contributors.

"That Mr. Stevens be advised to invite the United States Inspectors, and other prominent engineers, to be present at the experiments."

On the 20th of September last, Mr. Stevens received permission from the Secretary of War, at the instance of the President, to make the experiments on the Government reservation at Sandy Hook, and to that place he transported the experimental boilers, with the necessary instruments, material and shed accommodation.

The boilers to be experimented with were nine in number; they were conveniently arranged on a well-chosen piece of ground enclosed by a high board fence, and were provided with the requisite pressure and water gauges. The former were expressly manufactured for the occasion, and had been carefully tested. Five pressure-gauges were placed near each boiler tried, under the protection of two bomb-proof; and two, tested to a pressure of 500 lbs. per square inch, were placed side by side at a safe distance from the boilers (about 250 feet on the first day, and 450 feet on the second day of the experiments) with which they communicated by a pipe of suitable length; while in this position, their indications were compared with those of the tested pressure-gauges at the boilers, and found to agree. All of Mr. Stevens' arrangements were judiciously made, and nothing was wanting to their accuracy and completeness.

EXPERIMENTS ON THE 22D OF NOVEMBER, 1871.

On the 22d ultimo, in accordance with a notification from Mr. Stevens, we proceeded to Sandy Hook, and witnessed the first experiments in company with the following gentlemen, who are largely interested, practically and scientifically, in the design, construction and use of steam boilers:

Joseph Belknap, Inspector General of Boilers; H. Birdsall, Inspector of Boilers; R. B. Davenport, Reporter for the New York "Herald"; J. B. Collin, Mechanical Engineer of the Pennsylvania Central Railroad; Coleman Sellers, President of the Franklin Institute, Philadelphia; Dr. Wm. H. Wahl, Secretary of the Franklin Institute, Philadelphia; Jacob Naylor, of Philadelphia; Wm. M. Henderson, of Philadelphia, Mechanical Engineer; E. H. Shallcross, of the Select Council of Philadelphia; Wm. Fisher Mitchell, of Philadelphia; Thomas J. Lovegrove, of Philadelphia; R. H. Thurston, Prof. Mechanical Engineering, Stevens' Institute, Hoboken; A. Fletcher, W. Fletcher, Builders of Steam Engines and Boilers at New York; C. H. Haswell, Examiner of Steam Machinery for the New York Insurance Companies; Norman Wiard, John McCurdy, James Miller, Messrs. Phinney & Hoffman; David Saunders, of the firm of J. Nason & Co., New York; Erastus W. Smith, Mechanical Engineer; W. E. Worthen, Mechanical Engineer; Robert Allen, Ralph Walker, G. H. Clemens, John Stuart, C. M. Bolen, T. S. Crane, John Dunham, Andrew Fife, John Fish, John McGowan.

The first experiment was made on a boiler built by Fletcher, Harrison & Co., in 1858, and taken out of the steamboat "Joseph Belknap" in July last, after having been thirteen years in use. It is of the ordinary upper return-flue type,

with a rectangular front, 7 feet 8 inches long, 6 feet 6 inches wide, and 6 feet 11 inches high, containing two furnaces, each of which was 2 feet 9 inches wide and 7 feet long; the top of this front is semicircular and single riveted. The remainder of the shell is a cylinder of 6 feet 6 inches diameter and 20 feet 4 inches length, unbraced, single riveted, and with a flat end. The total length of the boiler is 28 feet. The iron of which the shell is composed is a large $\frac{1}{4}$ inch thick, and all the flat surfaces are braced every 7 inches. The top of the furnaces is flat and braced to the semicircular top of the shell immediately over it; and from this semicircular top there rises the usual cylindrical "steam chimney" or annular steam-drum, surrounding the lower portion of the chimney and braced to it. The steam chimney is 4 feet in external diameter, 2 feet 8 inches in internal diameter, and 10 feet 5 inches in height above the shell. The lower flues are ten in number, and 15 feet 9 inches long; two of them are 16 inches in inner diameter, and the remainder are 9 inches in inner diameter. The upper flues are 12 in number, 22 feet long and $8\frac{1}{2}$ inches in inner diameter. The least water space between the flues is $2\frac{3}{4}$ inches in the clear. All the flat water spaces of the boiler are 4 inches wide, including thicknesses of metal. The grate surface is $38\frac{1}{2}$ square feet. The water-heating surface in the furnaces is 80·09 square feet; in the combustion chambers, 31·84 square feet; in the lower flues, 428·70 square feet; in the back connection, 76·92 square feet; in the upper flues, 587·48 square feet; and in the front connection, 57·98 square feet; making a total water-heating surface in the boiler of 1,263 square feet. The steam superheating surface in the steam chimney is 84 square feet.

This boiler, on the 2d of September last, was subjected, at Hoboken, to a hydrostatic pressure of 112 pounds per square inch, which broke a few of the braces without altering the form of the semicircular top of the rectangular front. After being repaired, it was again subjected, at Sandy Hook, on the 4th of November last, to a hydrostatic test of 82 pounds per square inch, without the rupture of any part; and on the following 15th of November it was subjected to a steam pressure of 60 pounds per square inch, without fracture.

In the experiment of the 22d of November, which we witnessed, the fuel used was wood, and it was intended to burst the boiler by steam pressure under the condition of 12 inches of water above the top of the flues, but it was found that the pressure could not be raised above 93 pounds per square inch, owing to the excessive leakage of steam from the seam joining the steam chimney to the boiler shell. At the above pressure no fracture occurred, but the form of the semicircular top of the rectangular front underwent a change. The experiment was only of value in showing the strength of a boiler of this type and construction after thirteen years' service in a vessel.

The next experiment was made on a rectangular box, built to represent the flat water space or water-leg of the "Westfield's" boiler, recently exploded at New York on board that vessel, with great destruction of property and life.

This box was 6 feet long, 4 feet high, and 4 inches wide, over all. The two side plates were of the best flange fire-box iron, $\frac{5}{16}$ of an inch thick, manufactured by the Abbott Iron Company. The plates were held together by a single row of rivets at their edges, passing through a frame made of wrought iron bars, mitred at their ends, and having the same outside dimensions as the box. These bars were $3\frac{3}{4}$ inches wide, 2 inches deep, and perforated at the centre line by the

holes for the rivets. The side plates were braced together, every 8¾ inches one way and 9½ inches the other way of their surface, by bolts of 1⅛ inch diameter, with threads cut upon each end and screwed into corresponding threads cut in the plates, over which both ends of the bolts were slightly—and but very slightly—riveted. The box was placed on one edge upon an 8 inches thick brick wall, and was enclosed with side walls of brick masonry, with the exception of a strip 15 inches deep at the top and 12 inches wide at one side, which protruded into the air, and to which the gauges were attached. The enclosed portion of the box was heated by two small furnaces without intercommunication, the fire-grates of each being 27 inches long and 14 inches wide. The fuel was wood, and the products of combustion were discharged through two sheet-iron pipes. The surface of the box exposed to the fire was 19½ square feet, and was all water-heating surface, as the box was filled with water to within nine inches of its top. Of the total interior height of the boiler, therefore, 37 inches were occupied by water and 7 inches by steam.

The fires being brought to steady action, and steam raised to the atmospheric pressure, the opening for the escape of the latter was closed, and the pressure rose as follows, for the corresponding times, namely:

Time P. M.		Steam pressure in pounds per square inch above the atmosphere.	Time P. M.		Steam pressure in pounds per square inch above the atmosphere.
Hours.	Minutes.		Hours.	Minutes.	
3	18	0	3	36	51
3	20	4	3	37	54
3	21	5	3	38	58
3	22	7	3	39	65
3	23	9	3	40	72
3	24	11	3	41	78
3	25	13	3	42	86
3	26	15	3	43	94
3	27	18	3	44	100
3	28	20	3	45	110
3	29	23	3	46	117
3	30	27	3	47	126
3	31	30	3	48	135
3	32	34	3	49	147
3	33	38	3	50	160
3	34	44	3	51	165
3	35	49			

When the pressure reached 165 pounds to the square inch, the box exploded with a loud report, completely demolishing the brick-work by which it was enclosed. The two sides were hurled in exactly opposite directions, and to about equal distances, at right angles to their surfaces. The fracture had occurred in one plate only, and was along the whole riveted seam joining it to the frame. For a large part of the length of the seam, this plate was torn out between the rivets, and for the remaining part the rivets were sheared. The other plate was not fractured, nor were the bars of the frame broken; the plate and the frame remained riveted together, but not uninjured—all the bars of the latter being bent considerably inwards, forming an irregular curve of from four to six

inches versed-sine. Both plates were bulged out irregularly, so as to be about nine inches dishing, and the bulging took place near the bars. Not one of the bolts was broken, and neither the threads upon their ends, nor the threads in the plate, were stripped or injured, but the slight riveting over of the ends of the bolts was broken off in all of them.

The fact that the plates did not rupture at the centre, under their great amount of bulging, (and only one of them tearing off at the line of rivets along its edge,) shows the excellence of the metal which endured this great, almost instantaneous, and permanent stretching without fracture; and to this same extensive stretching must be attributed the escape of the screw threads on the ends of the bolts, and in the plates, from injury. The plate, by stretching, simply enlarged the diameter of the hole in which the threads were cut, until the bolt, thus left free, slipped through without injury to its threads, only breaking off the slight riveting over of its ends. Had these bolts been secured by nuts on the outside of the plates, the box would have borne an enormously greater pressure than that which exploded it. Between the bolts there was a small permanent stretching of the plates, giving each space between the bolts a slightly dishing or bulged form, in addition to the general bulging of the plates, thus forming a system of secondary bulges, as it were; and around every bolt both plates were strongly marked by a congeries of circular crispations.

The conclusions from this experiment are: That a gradually accumulating steam pressure in a boiler can produce a true explosion, violently hurling its fragments, with a loud report, to a considerabe distance, even though 84 per centum of its capacity be filled with water; and—That screw bolts should not be used in boiler construction without nuts, or having, as an equivalent, a large portion of their ends formed into massive rivet heads; because the stretch of the plates is sufficiently great, under a much less pressure than will fracture the bolts or strip their threads, to allow the latter to slip through uninjured.

Previous to this experiment, the box had been subjected, at Sandy Hook, to a hydrostatic pressure of 138 pounds per square inch, and to a steam pressure of 102 pounds per square inch, without fracture.

Experiment on the 23d of November, 1871.

On the 23d ultimo, a last experiment was made by exploding a boiler in the presence of the undersigned and the following gentlemen, namely:

Capt. W. W. Woolsey, Superintendent of the Jersey City Ferry; William and Andrew Fletcher, of the firm of Fletcher, Harrison & Co., Engine and Boiler Makers; Anning Smith, Superintendent of the North Shore Ferry Company; J. B. Collin, Mechanical Engineer of the Pennsylvania Central Railroad; William A. Dripps; Thomas Lingle, of the Camden and Amboy Railroad; Wm. Brown, of the Camden and Amboy Railroad.

The boiler that was exploded during this experiment was built by T. F. Secor in 1845, and taken out of the steamboat "Bordentown" in August last, after having been 25 years in use. When taken out, the Inspector's certificate allowed it to be worked with a pressure of 30 pounds per square inch. It was a horizontal fire-tube boiler, with the tubes returned immediately above the furnace and combustion chamber.

It had but one furnace, and that was 11 feet 5 inches in width, with grate bars 7 feet in length. The top of the furnace and the top of the combustion chamber were flat, and braced to the flat top of the shell above them by rectangular braces 2 inches by $\frac{1}{2}$ inch in cross section, placed 17 inches apart crosswise the boiler, and 12 inches apart lengthwise the boiler, each brace holding a flat surface of 204 square inches, to which it was attached by crow-feet so arranged that the flat surface between the sustaining rivets was 12 inches square. The flat water-spaces were braced at intervals of 8 inches in one direction and 12 inches in the other, by 1 inch diameter screw-bolts, each of which held a flat surface of 96 square inches. The iron plates of the boiler were a large $\frac{1}{4}$ inch thick.

The tubes were of iron, and 384 in number, arranged in 8 rows vertically and 48 rows horizontally. Each tube was 2 inches in outside diameter and 12 feet in extreme length. The total height occupied by the tubes from the lower side of the lower tube to the upper side of the upper tube, was 22 inches. The tubes were divided into sixteen groups, and the groups were separated by water spaces two and one-sixteenths inches wide in the clear vertically, and $1\frac{1}{4}$ inch wide in the clear horizontally. From the lower side of the lower row of tubes to the top of the furnace and combustion chamber, was a space six inches in width, for water circulation. The bridge-wall and the bottom of the combustion chamber were of brick. The furnace had no water-bottom, but its side legs of $4\frac{1}{2}$ inches width rested in a pan which covered the entire area beneath the furnace.

The shell of the boiler was rectangular with the exception that the vertical sides were joined to the flat top of quadrantal arcs of 37 inches radius. All the seams were single riveted.

Upon the centre of the top of the boiler was a cylindrical steam-drum of 6 feet diameter and 8 feet, 8 inches height.

The flat water-space at the front of the furnace was $4\frac{1}{2}$ inches wide, and that at the back end of the boiler was 5 inches wide, including thicknesses of metal.

The width of the boiler was 12 feet 2 inches, its length was 15 feet 5 inches, and its height, exclusive of the steam-drum, was 8 feet 6 inches.

The shell was braced very unequally. Each upper horizontal brace, $1\frac{1}{8}$ inch large in diameter, sustained the pressure upon a surface 28 by 12 inches or 336 square inches; and each rectangular vertical brace adjacent the sides, 2 inches by $\frac{1}{2}$ inch in cross section, sustained the pressure upon a surface 19 by 12 inches or 228 square inches; these were the weakest places.

The following were the grate and water heating surfaces of the boiler:

Grate surface	79 $\frac{11}{12}$ square feet.
Heating surface in furnace	180 "
" " in combustion chamber and back connection	103 "
" " in tubes	2171 "
" " in uptake	64 "
Total heating surface	2518 "

On the 2d of September last, this boiler was subjected to a hydrostatic pressure of 60 pounds per square inch, when twelve crow-feet gave way. After being repaired, it was again subjected on the 4th of November last, when erected at Sandy Hook, to a hydrostatic pressure of 59 pounds per square inch,

which it bore without fracture; and on the 16th of November last, it was subjected to a steam pressure of 45 pounds per square inch, which it also sustained without fracture.

The fuel used in the experiment was wood, and the water-level in the boiler was 15 inches above the highest point of the tubes. When the fire had been brought to steady action, the pressure of the steam gradually increased at the following rate, commencing with the pressure of 29½ pounds per square inch:

Time P. M.		Steam pressure in lbs. per square inch above the atmosphere.	Time P. M.		Steam pressure in lbs. per square inch above the atmosphere.
Hours.	Minutes.		Hours.	Minutes.	
12	21	29½	12	30	46½
12	23	33½	12	31	48½
12	25	37½	12	32	50
12	27	41	12	33	52
12	29	44½	12	34	53½

At the pressure of 50 pounds per square inch, some of the braces in the boiler gave way with a loud report, and when the pressure of 53½ pounds was reached, the boiler exploded with terrific violence. The steam-drum and a portion of the shell attached to it, forming a mass of about three tons weight, were hurled to a great height in the air and fell to the earth at about 450 feet from the original position of the boiler, crushing several trees in their fall. Two other large fragments fell at less distances, while smaller ones were thrown much farther. Almost the whole of the boiler was literally torn into shreds which were scattered far and wide, the only portion remaining where the boiler had been, being the tubes. These, though considerably distorted, were otherwise uninjured. Both tube-plates had been blown from the tubes in opposite directions, and at the same moment, for nearly all the tubes were found lying in a heap on the ground immediately beneath the place they had occupied in the boiler, the riveting of their ends over the plates having been simultaneously stripped. The top of the furnace and the top of the combustion chamber, which, in the boiler, were immediately beneath the tubes, had entirely disappeared into débris, as had also the sides and ends of the shell. The boiler seems to have first yielded by the fracture of the upper row of horizontal braces. The loud report heard when the pressure obtained 50 pounds per square inch was probably caused by their breaking. The larger masses were all thrown in one direction—at right angles to the side of the boiler; but the smaller fragments were projected radially in all directions, as from a centre. Two heavy bomb proofs, constructed of large timbers and sand for the protection of the other boilers, were dislodged and a part of the fence of the enclosure was destroyed, by the impact of the flying fragments. The crow feet, in most cases, remained firmly attached to the shell, and the braces had parted—probably in the welds—leaving the ends still secured to the crow feet. The screw bolts which braced the flat water spaces, had slipped from their fastenings in the plate without injury to the screw threads either upon them or in the plate. The latter was permanently bulged or dished between the bolts, and this stretching of the metal had, by its enlargement of the holes, allowed the screw ends of the bolts to draw out without injury to the threads, either on the bolts or in the plates.

The ground beneath, and for a considerable distance around where the

boiler stood, was saturated with the water of the boiler, in fact made into mud, and the adjacent grass and small shrubbery were so drenched that an ordinary boot was wet through by walking among them. At seven minutes before the explosion took place, the water gauge on the boiler was examined and found to indicate the water level 15 inches above the top of the tubes.

The conclusions to be drawn from this experiment are the following:

1st. An old boiler, containing a large mass of water above the highest point of its heating surface, can be exploded with such complete destruction as to reduce it into mere débris, and hurl the fragments in all directions with a force that no ordinary construction of building or vessel could withstand.

2d. That the pressure required for so devastating an explosion, is the very moderate one of 53½ pounds per square inch.

3d. That with only a wood fire, generating a far less quantity of heat in equal time than a coal fire, there were required only thirteen minutes to raise the pressure from the Inspector's working allowance of 30 pounds per square inch, to the exploding pressure of 53½ pounds per square inch, showing that a few minutes absence or neglect of the engineer, coupled with an overloaded or inoperative safety valve, are all that are needed to produce the most destructive steam boiler explosion, even with an old and unequally braced boiler, in which it might be supposed a rupture of the weakest part would precede other fracture, and allow the reduction of the pressure without doing further injury.

4th. That in accounting for either the fact of an explosion, or for its destructive effects, there is no necessity for hypotheses of low water, enormous pressures, instantaneous generations of immense quantities of steam, superheated steam, the formation of hypothetical gases, development of electricity, &c., &c. The most frightful catastrophe can be produced by simply gradually accumulating the pressure of saturated steam to a strain at which the strength of the boiler yields, nor need that pressure be much above what is ordinarily employed with boilers of this type.

5th. That there is no flashing of the boiler water into steam at the moment of an explosion. On the contrary, with the exception of the small portion of this water vaporized (after the reduction of the pressure owing to the rupture of the boiler) by the contained heat in it between that due to the temperature of the streams of the exploding pressure and of the atmospheric pressure, it remains unchanged, and is thrown around, drenching the objects near it, and scalding whatever it falls upon.

6th. The weakest portion of the boiler braces was in their welds.

7th. The equal stretching in all directions of the boiler-plates between the screw-bolts, due to their bulging under the pressure, was sufficient to permit the slipping out of the bolts without injury to the screw-threads either upon them or in the plates.

8th. That this experiment has conclusively disposed of several theories of steam boiler explosion, replacing vague conjecture and crude hypothesis with exact experimental facts, and, by thus narrowing the field for the search of truth, has made its discovery more probable.

All of which, together with drawings of the boilers experimented with, are respectfully submitted by, Sir,

Your Obedient Servants,

B. F. ISHERWOOD,
E. S. DE LUCE,
SIDNEY ALBERT,
} *Chief Engineers U. S. Navy.*

HON. GEORGE M. ROBESON,
Secretary of the Navy.

Chemistry, Physics, Technology, etc.

ON THE MINERAL RESOURCES OF NORTH CAROLINA.

By Fred'k A. Genth.

For a long time past the State of North Carolina has been noted for its great and varied mineral wealth, hence it became the favored field for speculations of every sort, some of these of the wildest character. It is not, therefore, to be wondered at that failure should have met most of those schemes, which contemplated mere stock operations in place of a legitimate development of the mines. However, as an unfortunate consequence of those speculative undertakings, an impression has been cast in our northern cities to the effect that the mineral riches of that state were more imaginary than real. The fallacy and injustice of such a conclusion were fully demonstrated to me twenty years ago, during a residence of nearly two years in the State, and since that time my faith in the mining resources of North Carolina has been strengthened by frequent visits as an expert, during which I have examined most of the gold, silver, copper, lead, zinc and iron mines of the central counties. In addition to those many opportunities of acquiring positive evidence of the mineral wealth of that State, it was my good fortune to spend a great part of last summer in North Carolina in company with Prof. W. C. Kerr, the very able State Geologist, at whose request I visited the principal mineral localities of the State for the purpose of working up the mineralogy for the geological report. My field for examination has been quite extensive, embracing, more or less, about thirty-two Counties of the State.

As one of the results of the geological survey of North Carolina, it may be interesting here to state that it has already contributed to the development of several mining localities, which have invited the attention of northern capitalists; other mining properties are in process of negotiation, and I have no doubt that, when better known, many other mines, which at present are neglected, will command the attention they justly deserve, offering, as they do, inducements for safe and profitable investment.

Although my labors in North Carolina in connection with the geological survey were generally directed to the mineralogy of the State, I have nevertheless made numerous observations, and acquired many facts which may be interesting to the members of the Franklin In-

stitute. I intend giving a brief account of the vast mineral resources of North Carolina, but ere I describe the occurrence of the different ores, it may not be amiss to sketch, in a concise way, the general outline of the geology of that State, without, however, entering into a geological discussion with reference to the position and age of the various rocks, but simply confining myself to their petro-graphical determinations.

Almost the whole State of North Carolina is made up of gneissoid or granitic rocks, alternating with strata of argillites, quartzites and talcose, chloritic and micaceous slates, all more recent rocks, resulting from the destruction of the older.

These are overlaid, in its eastern and south-eastern portion, for a distance of from ninety to one hundred miles from the coast by tertiary and cretaceous deposits, with numerous marl beds, of much local importance for the agricultural development of this portion of the State. Many of these beds contain small quantities of lignite and pyrite, but not in sufficient quantities to be of any commercial value.

The older formations are arranged in nearly parallel bands or belts, which cross the State in a north-east to south-western direction. The tertiary and cretaceous formation rests immediately upon a belt of quartzites and slates bearing N. 25—30° E. with a southeasterly dip, and these are underlaid by granite and gneissoid strata, which border them on the west and form the most eastern granite belt, known as the Raleigh belt, which occupies the greater portions of Warren, Franklin and Wake Counties, with Raleigh as a centre; and extends from there southwestwardly through Richmond County into South Carolina. It consists, to a large extent, of a granular granite, composed principally of orthoclase, greyish white granular quartz, and very little mica, which is frequently biotite. In many places the granite is a real granulite; in others it graduates into gneiss, and, here and there, into hornblendic strata.

The Raleigh belt is overlaid by very extensive beds of slates, argillite, quartzite, etc., with a north-west dip, traversing Granville, Person, Orange, Alamance, Randolph, Moore, Montgomery, Stanley, Anson, Union and the south-east part of Davidson, Cabarrus and Rowan Counties.

To the west of these slates, which have been called *taconic* slates by Emmons, another band of the oldest rocks is again observed. It has been called the Greensboro' and Salisbury granite belt, and occupies

the principal portion of Caswell, Rockingham, Guilford, Forsythe, Davie, Davidson, Rowan, Iredell, Cabarrus, Mecklenburg and the eastern portion of Gaston, Lincoln and Catawba Counties. The granites are often granulites, consisting only of orthoclase and quartz. In many places they became porphyritic, by the dissemination of large orthoclase crystals throughout the mass; again they change to gneiss and micaschist, and frequently, through a gradual admixture of hornblende, they turn to syenite, hornblendic gneiss, hornblende-slates and even diorite. These hornblendic rocks are interlaminated with the granite and gneiss, and their gradual passage from one into the other are evidence of their cotemporary origin. As these hornblendic or dioritic rocks are less readily decomposed, they often form vein-like walls through the other rocks, so-called "trap dykes," and as the result of their partial disintegration, the surface is covered with rounded boulders.

Accumulations of various iron ores, hematites and magnetites, form bands in this belt of gneissoid rocks.

Another band of more recent slates, characterized by several important beds of limestone and magnetic iron, passes from King's Mountain in a northeasterly direction through Gaston, Lincoln and Catawba Counties; here it is interrupted, but it occurs again in Davie, Forsythe, Yadkin and Stokes Counties.

Proceeding in a westerly direction, we again come into the region of the oldest gneissoid and related rocks, very similar to those of the more eastern belts. These make up the bulk of the counties of Wilkes, Caldwell, Alexander, Catawba, Cleveland, Burke, McDowell, Rutherford, Polk and Henderson.

A narrow band of slates borders this granite formation through Surry, Wilkes and the north-western corners of Caldwell, Burke, McDowell, Henderson, and passes through Transylvania County into South Carolina. These slates appear to be connected with those of Stokes county. In this band of slates in several localities there occurs a peculiar quartzite, which, by a minute admixture of mica between the rounded particles of quartz, forms the so-called "flexible sandstone" or itacolumite. The principal localities in which it has been observed are Linville in Burke, Bending Rock Mountain in Wilkes, and Sauratown Mountains in Stokes Counties. In this narrow belt of slates, several valuable limestones and iron ore beds have been discovered.

The last belt of gneissoid or granitic rocks occurs west of these slates.

It is largely made up of gneiss and hornblende slates, with a frequent admixture of garnets and crystals of cyanite. These rocks occur in Alleghany, Ashe and Watauga Counties; they are interrupted, however, in the southern portion of the latter and the northern part of Mitchell county by a narrow strip of slates, which extends into Tennessee; but they then continue through Mitchell, Yancey, the greater portion of Madison, Buncombe, Haywood, Jackson, Macon and Clay Counties, and the southeastern part of Cherokee County. In this belt large veins of granite occur, with massive accumulation of orthoclase and muscovite, associated with garnet, tourmaline, beryl, etc.; also lenticular masses of magnesian rocks with chrome ores, either chloritic slates, etc., or granular chrysolite, which is the parent rock, by the alteration of which, in Pennsylvania, for instance, the serpentines have been produced. The extreme north-western limits of the Counties of Mitchell, Madison, Haywood, Jackson, Macon and the greater portion of Cherokee, are again occupied by slates, frequently inclosing beds of marble and granular dolomite interlaminated with beautiful talcslates or micaceous slates, containing large crystals of staurolite, garnet, etc.

I have yet to mention as a very important formation the "triassic," which occupies a portion of the central counties of North Carolina. Resting upon Emmon's so-called taconic slates, narrow bands of shales and sandstones pass through Granville, the eastern edge of Orange and the western of Wake County, which in Chatham and Moore Counties widen and contain several valuable beds of coal; the formation continues through the south-east edge of Montgomery, thence through Anson County into South Carolina. The dip of these strata is south-east, and they form the south-eastern portion of the triassic formation, the central portion of which has been removed by erosion, whilst the north-west portion, with a north-westerly dip and resting directly upon gneissoid and granitic rocks, appears again in Rockingham and Stokes Counties, where it shows sandstones, shales and numerous outcrops of coal beds.

The gneissoid or granitic strata, as well as the slate formation, are frequently intersected by metallic deposits, either in veins and associated with quartz as a vein rock, or in ore beds, interlaminated with the strata, and forming a portion of the formation.

I will now proceed to the consideration of the occurrence of the different metals and other valuable minerals:

Gold. According to the earliest records the first piece of gold

found in North Carolina was picked up in 1799, in a little branch at the Reid plantation, Cabarrus County. It weighed between three and four lbs., and was kept several years without its real character being suspected; subsequently it was sold to a jeweller in Fayetteville for $3.50. When its true character became known, search was made for more, and fourteen lumps, weighing in the aggregate 153 lbs. troy, were obtained at the same locality.

The gold veins and gravel deposits were afterwards discovered; and for a considerable time gold operations were conducted in many localities on a comparatively large scale. The discoveries of gold in California, where a far richer harvest was promised, led to the abandonment of many of those enterprises; other causes have also influenced in the same direction, as, for example, the difficulties connected with deep vein mining, and the impossibility of extracting the gold by the imperfect and slow machinery then principally in use, the Chilean Mill and Arastra, etc., from heavy ores like pyrite, &c., which nature has not already decomposed. With the exception of minute quantities of telluride, in the *very rare* mineral nagyagite, at the King's mountain mine, gold in North Carolina is always found in the metallic state. It is rarely quite pure, but generally alloyed with more or less silver. It occurs in crystals or crystalline masses, in thin plates or laminæ, between the foliation of the slates or through associated minerals, such as quartz, pyrite, galenite, zinc-blende, etc., in such a fine state of division that it is generally invisible to the eye.

It has been observed in four different geological positions:

1st. It is met with in the *mass* of the gneissoid, granitic and hornblendic rocks.

2d. In quartz veins, often associated with pyrite, chalcopyrite, galenite, tetradymite and other minerals.

3d. In ore beds, cotemporary with the strata of rocks in which they are found, as in chloritic and talcose slates, argillites, quartzites, etc.

4th. Loosely in the soil and decomposed rocks, especially in gravel deposits, resulting from the destruction of the above first three formations. One of the most remarkable features peculiar to the rocks of the Southern States is their rapid disintegration.

The débris from these rocks forming the soil or ferruginous clay, remains in situ. This disintegration is frequently observed to a depth of over one hundred feet. Many of the railroad cuts show beautiful sections, and the study of these exhibits some highly interesting

features, which I shall mention, as they are of the greatest importance to a full comprehension of the subject.

In many places cuts may be seen which appear to have been made in a uniform mass of clay, which, in general, is ferruginous; on close observation, however, it is easy to recognize that the *apparently* uniform clay stratum belongs to two distinct formations.

Immediately below the soil, which may be covered by vegetation, the ferruginous clay will be seen to contain, here and there, small fragments of quartz in angular pieces, with the edges more or less rubbed off, disconnected and not occurring in regular seams or veins; the number of those quartz pebbles gradually increases at a greater depth, until they form a regular stratum of gravel.

Some of those gravel beds are hardly perceptible; others vary from a few inches to over thirty feet in thickness.

When the great denudation took place, these fragments of quartz deposited themselves upon the *then* unaltered bed rock—the granite, gneiss, micaschist, slate, etc.; but after this period the disintegration of the rock continued, and it is natural that the same kind of clay should have resulted from the same parent rock.

Therefore we find, just below this gravel bed, ferruginous clay as above, but a closer investigation shows a great difference and especially two striking facts: in the first place the stratification can be observed and followed to the underlying, undecomposed rocks, and secondly, the quartz, which is found in the same, occurs not in loose angular pieces, but in regular seams or veins, in their original position.

In some of the auriferous regions of North Carolina, such quartz veins are very numerous; in others, they are less frequently met with.

Most of them are exceedingly small, varying in width from the thickness of a knife's blade to a few inches, and often extending in depth but a few feet; some bulge out and form nests or pockets in the rocks, while others again are of enormous size, and are known to exist as deep as they have been developed, which, in a few rare instances, is down to 200—300 feet.

Many of these quartz veins are in reality beds, as they coincide in strike and dip with the stratification, whilst an equally great number run in every conceivable direction, and dip just as irregularly.

The greater portion of these quartz veins contain *no* gold, or only such a small quantity that they could not be profitably worked, especially the large veins of vitreous and milky quartz.

Many of the small veins, principally those which contain granular or saccharoidal quartz, are rich in gold.

Some of the large veins, especially those containing much cellular quartz, have frequently been found to be the most productive. This cellular quartz results from the decomposition of pyrite, which once occupied the now empty spaces; leaving them either occasionally quite free from iron, or more generally rusty and more or less filled with limonite. These, the so-called brown gold ores, are the best and most easily worked. At a greater depth of the veins, where the pyrite is not decomposed, the gold is so much mixed with heavy sulphurous ores that, with the present system of operations, it cannot be extracted with profit; in many cases the gold disappears entirely.

Most of these gold veins in North Carolina were abandoned, when the iron and copper pyrites increased too largely, and before they had been wrought deep enough to contain copper ores in paying quantities.

The gold in these mines is not evenly distributed through the mass of the gangue; the veins often contain entirely barren portions alternating with rich ones, the latter called shoots of ore or chimneys.

Such shoots are in reality veins inside of a vein, and are frequently quite regular in their dip; the ores at the foot wall are generally richer than those at the hanging wall.

Many gold mines of this description have formerly been worked, and many of them undoubtedly are still of great value.

In Guilford County there were the McCulloh and Fisher Hill mines; in Cabarrus County, the Phœnix, Vanderburgh, Cullen, Pioneer Mills mines; in Mecklenburg County, the Capps, McGinn, Rudesill mines; and numerous others. At present, almost every one of them are unworked; some explorations are carried on in Cabarrus County, and in Mecklenburg County the McGinn and the Wilson mines are the only ones in operation, and that on a small scale only.

At the McGinn mine they have a 5-stamp battery and amalgamated copper plates, also roasting ovens to decompose the sulphides; at the Wilson mine there is a 10-stamp battery with amalgamated copper plates, all after California patterns.

Many of the quartz veins in the slates, differing in strike and dip from the inclosing slate, carry gold, especially those which contain cellular and cavernous quartz, associated with limonite, hematite, siderite, pyrite, chalcopyrite, etc.

Some of them are highly promising, as, for instance, those of the

Conrad Hill mine, in Davidson County; but, unfortunately, not a single vein has been sufficiently developed in depth to form a just appreciation of its value.

The gold deposits, which are cotemporary with the slates themselves, are of far greater importance than the true gold veins.

The talcose, chloritic, micaceous or arenaceous slates in which they occur, contain portions which are more or less charged with gold. The gold in these slate beds, like the slates themselves, is derived from the destruction of the older rocks, and has been deposited simultaneously.

The width of these auriferous beds varies from a few inches to from 60 to 70 feet.

The gold in them is often found without any admixture, and the auriferous strata shows no line of demarcation, and cannot be distinguished from the barren layers; but, generally, and subsequently to its deposition, it has been acted upon by chemical agencies, dissolved and precipitated again, and has assumed a crystalline structure; it has accumulated in strings which sometimes form lenticular and more highly auriferous masses in the beds, and is associated with crystalline quartz, pyrite, chalcopyrite, galenite, blende, mispickel, etc.

These are often parallel with the slates, and so close together that they can be worked by the same operation, especially where the slates between are also auriferous.

The Steele mine, in Montgomery County, and the Stewart mine, in Union County, are examples of this occurrence.

These gold mines have proved to be the only reliable ones in depth, and, if they are found to be rich enough for working, they can be depended upon for the future.

To this class belong the mines at Gold Hill, in Rowan County, which have already produced not less than $2,000,000, and have reached a depth of 750 feet. Although this appears to be a very large production, I do not hesitate to say that perhaps four-fifths of all the gold in the ore, which is a talco-micaceous or chloritic slate, intermixed with pyrite, magnetite, and a little quartz, has been lost in the tailings, on account of the very imperfect process used for the extraction of the same.

The King's Mountain mine, of Gaston County, also belongs to this class. The gold is, to a great extent, contained in a quartzose limestone, and is associated with very small quantities of pyrite, gale-

nite, chalcopyrite, but also with the very rare tellurides of lead, altaite, and with nagyagite, a telluride of gold and lead.

In some places this ore bed is over thirty feet in thickness, and has been worked to a depth of 200 feet, but longitudinally only to a very small extent, not over 250 feet.

This mine is also said to have produced over $1,000,000. The machinery used for the reduction of the ores are a 20-stamp battery with amalgamated copper plates, etc.

There are at present no other mines belonging to this class in operation, but there is no doubt that Montgomery, Union, Stanley, Rowan, Davidson, Randolph, Gaston and Cherokee Counties have many localities, where profitable and successful mining operations might be carried on.

In gold mining operations, the deposits which result from the disintegration of the rocks, and subsequent denudation, are undoubtedly of the greatest importance; there the gold which was contained in the rocks and in the small auriferous veins (which have been broken up into fragments) has been concentrated by nature, and in many places has been deposited, with the remnants of the veins, in the gravel beds, which I have already mentioned.

Those gravel beds occur to a greater or less extent throughout the whole gold region; the oldest gneissoid rocks as well as the slate formation contain them.

The quartz in general is not water-worn, only the sharp edges are rounded. Many pieces still present the shape and thickness of the veins whence they came.

The most extensive gravel deposits exist in the South Mountains, on the headwaters of the first and second Broad River, Muddy Creek and Silver Creek, in the Counties of Rutherford, McDowell, Burke, Caldwell, also in Polk, and Cleveland; embracing an area of over 200 square miles.

They appear to cover the greater part of the land, rise often to a considerable height on the slope of the hills, but are naturally more concentrated in the bottoms and flat lands. The gravel beds in this region vary in thickness from a few inches to thirty feet, and are covered with soil and clay, which is also more or less auriferous, although much poorer than the gravel beds below.

These deposits have been worked since about 1830, and before gold was known in California many thousands of hands were at work digging and washing in a rude way, yet many millions of dollars were

produced without the help of any complicated machinery, and without the knowledge of a proper use of water.

Since that time very little has been done; in some instances the old gravel was worked over again, and has made fair returns to the adventurers.

Very large tracts of land, containing extensive and valuable deposits, have never been touched, and, by the introduction of the Californian hydraulic system of operations, a safe and very profitable business could be carried on.

The gold is rarely found in nuggets; generally as fine dust and in small grains. Its fineness averages about 825 thousands. It is associated with numerous interesting minerals, such as platinum, diamond, zircon, xenotime, monazite, and many others.

Experiments with vein-mining in this region have not proved successful; the rich veins are too narrow in width, and of too limited extent in depth, and the large veins do not contain enough gold to be advantageously worked.

A small region of valuable gravel beds exists in the gneissoid rock and micaceous slate of Franklin and Nash Counties, in the eastern part of the State. It has been most extensively prospected at the Portis mine, where it is very rich, and has been worked since about 50 years, having produced, it is said, over $1,000,000.

The productive gravel is here the result of the disintegration of numerous small granular or sugary quartz veins, and very fine specimens of gold in such quartz are frequently met with.

The fineness of the Portis mine gold was generally about 985 thousands.

There are enormous gravel piles at the mine—the remnants of former operations.

Some very important but expensive experiments have been made at this mine.

Machinery was here erected for crushing and amalgamating the gravel, which, being part of gold veins, was thought could be profitably worked for gold.

The result was precisely what my own examination of the place convinced me it should have been—*a failure;* because, whilst the gravel may contain some very rich specimens, the whole bulk is too poor to be worked with profit. This is accounted for from the fact, which I have already intimated, that the gold in the gravel deposits, principally, is the *loose* gold, which had existed in the rocks and be-

tween their laminæ, or that from the *small* quartz veins, whilst the large veins are mostly *barren*. In a region which contains many small veins, the gravel deposits are generally valuable, even if the bulk of the beds has been made up from the destruction of large ones.

There are several highly important gravel deposits in Montgomery County, in the slate formation, some of which have produced a large amount of gold; the gold is mostly crystalline, in flat pieces, often covered with octahedral crystals, and in large nuggets; very little fine-grained gold has been found.

The best known deposit, which has produced large returns, but which is still, so to say, barely touched, is the so-called Christian mine.

The Swift Creek mine, about seven miles distant, produces gold of similar appearance.

West of the Blue Ridge several gravel deposits have been worked, to a greater or lesser extent, in Cherokee and Jackson Counties, also at Howard's Creek, in Watauga, and on the French Broad and New Rivers.

Throughout the whole gold region, every stream, branch and rivulet contains gold; and, as the washing of these is the most convenient way to obtain the precious metal on a small scale, there is hardly one which is not more or less worked, many of them up to their source.

Platinum. Only a few grains have been found in North Carolina, associated with gold in Rutherford and Burke Counties; and there is no prospect that it ever will be found in large quantities.

Silver, Lead, Zinc. I shall consider those three metals under one head, as they are always associated.

Silver is a rare metal in North Carolina. With the exception of the silver alloyed with gold, varying from 1 or 2 to about 20 per ct., in the gold from veins and gravel deposits of the granitic and gneissoid rocks, very little silver has been found in the veins of these strata.

The only localities which came under my notice were at the Baker mine, in Caldwell, and at Scott's Hill, in Burke County. There it occurs but rarely, in veins of auriferous quartz. At the latter place it is only observed after burning the ore, and a little fragment which I have seen makes me feel confident that it is present as cerargyrite, or chloride of silver.

Small quantities of argentiferous galenite and pyromorphite are associated with it.

Native silver has been observed with chalcocite or copper glauce at Gap Creek mine, in Wilkes County, and at the Asbury vein in Gaston County.

The only real silver mines of North Carolina are ore beds of zinc blende, mixed with galenite, in the argillaceous and talcose slates. The type of these is the old Washington mine, now Silver Hill, in Davidson County, which was discovered in 1838. Near the surface it formed a bed of carbonate of lead, having in many places films and plates of metallic silver disseminated through the mass of the ore. These ores were easily reduced, and produced handsome returns to the owners. This was, however, but of short duration. The undecomposed ores, which were a very fine-grained mixture of brown zinc-blende and argentiferous galenite, were soon reached, and presented great difficulties in the extraction of the precious metals.

When I was at the mine, about 22 years ago, an analysis of an average sample of between 2000 — 3000 tons of ore gave me about 45 per ct. of zinc, 21 per ct. of lead, about 8 ounces of silver per ton, with minute quantities of copper and gold. If the Philadelphia owners had abided by my advice, viz., to work the ores for zinc, and extract silver, copper and lead from the residues, they would probably still be in possession of this valuable mine.

The ore bed is large, and in one place has had a thickness of about 60 feet.

Occasionally it contains very rich spots, with native silver in lumps and filiform masses, or disseminated through the ore with argentite or highly argentiferous galenite; and besides these minerals this mine has furnished the most magnificent cabinet specimens of cerussite, pyromorphite, etc.

The mine is now 650 feet deep, and the ore is greatly mixed with slate. The purer masses are kept separate; the slaty ore is crushed and separated by buddles, etc., and the buddled ore is roasted and shipped to New York for the manufacture of the so-called Bartletts' white lead. The production of this mine is now about 400 — 500 tons per month.

Very similar ore is found about six miles north-east of Silver Hill. The vein has not been developed, and the work done at Silver Valley has not been productive.

The Hoover mine, about six miles from Silver Hill, contains gale-

nite, in a more coarsely crystalline variety, in a calcareous veinstone, and the Boss mine, two miles distant, has furnished handsome cabinet specimens of galenite in quartz.

The McMakin mine, about 1½ mile south-east from Gold Hill, is a very interesting one; the principal vein is a large vein of zinc-blende in talcose and argillaceous slates; it contains native silver, argentite, argentiferous galenite, and highly argentiferous tetrahedrite. The latter contains, according to my analysis, 10·53 per ct. of silver, and an average sample of ore of a 5′ vein, at 80 feet depth, which was sent to me about 11 years ago, yielded 246 ounces of silver per ton, worth about $334. The mine is not worked, but looks favorable enough to deserve fresh attention.

The Troutman mine, also in the neighborhood of Gold Hill, and one mile south-east of it, has been opened as a gold mine. It consisted of porous quartz, and yielded near the surface very rich ores, worth $50 per bushel; at the depth of 100 feet, where the sulphides are undecomposed, the ores yielded only $1, and contained a string of ash grey zinc-blende with pyrite, from 2 to 6 inches in width, which had increased to 18 inches when abandoned at a depth of 160 feet. These ores are well worthy of a fuller investigation, as they may be rich in gold.

I have already mentioned, when speaking of gold, the beds and veins of gold ore in Union and Montgomery Counties, as being frequently associated with zinc-blende. The string veins of the Steele mine principally consist of these and galenite.

At the Long (or Monroe) mine, in Union County, the quartz veins in the slates are richly charged with argentiferous galenite; but the veins have not been sufficiently explored to know whether it will increase in depth.

At the Lemmond (Marion) mine, a very remarkable vein or bed has been worked; it is irregular in size, sometimes widening out from a few inches to six feet. It consists of quartz, richly charged with brown zinc-blende and galenite, with small quantities of arsenopyrite, chalcopyrite, often intermixed with grains of electrum, a highly argentiferous variety of gold. Both the galenite and the zinc-blende are very rich. I have examined a *pure* specimen of galenite which did not show any admixture of *free* gold to the eye, but which yielded at the rate of nearly 30 oz. of gold and 86½ oz. of silver to the ton; and pure brown zinc-blende gave me about 32 oz. of silver and gold, nearly half of which was gold. This vein appears to have

a considerable longitudinal extension, and passes into the Steward mine property, formerly owned in this city.

At the latter mine, and at various other localities in this region, similar ores have been found, but the war has stopped all operations, and it will require capital and skill to develop this highly important mining district.

Galenite and zinc blende occur at several other mines, associated with gold ores, as at the Kings mountain, the Cansler and Shuford, and the Long Creek mines in Gaston county, etc. At Cedar Cove, McDowell county, in the limestones of the so-called taconic slates, at the Dobson mine, there is found an accumulation of yellow and yellowish brown zinc-blende mixed with lime. I have not, however, seen anything from there which looks encouraging.

Galenite and zinc-blende is associated with the gold ores at Murphy, Cherokee county. Highly argentiferous galenite occurs at several localities on Beech mountain, Watauga; argentiferous and auriferous galenite have been discovered at Flint Knob in Wilkes County, and I have seen specimens of it from Marshall, Madison County, Clayton, Johnson County, and Elkin Creek, Surry County, and also in several of the copper mines throughout the State, but I have no knowledge of any deposit of sufficient magnitude to be worked advantageously.

Tin.—No tin ore has been found in North Carolina as yet. Traces of this metal have been found in the tungstates of Cabarrus County, and in a micaceous slate in Gaston County, associated with garnet and columnar topaz (pycnite).

ON THE ABSORPTION OF GASES BY WATER, AND ON THE ORGANIC MATTERS CONTAINED THEREIN.

By G. W. Baird, U. S. N.

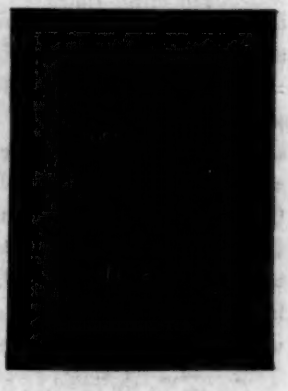
Our attention was called to this subject a few years ago by some attempts made to ærate water on board ship. We had been suffering from the flat oleaginous and insipid taste of the freshly distilled water, and in our endeavors to render it potable within a reasonable length of time, it was found that the subject was one of no small importance, and attended with many difficulties.

By exposure to the air from four to five days the water became sweet and potable, and by exposure to the foul gases of the bilge it also became potable and sharp.

By delivering the water warm into the ship tanks it became potable much sooner than when delivered cold, though it was a well established fact that gases are less soluble in warm than in cold liquid. The water as delivered appeared as clear as crystal, yet there was always a mass of filth deposited on the bottom and sides of the tank after the lapse of a few months.

ABSORPTION OF AIR.

By subsequent investigations it has been proven that the "sharpness" of the water is due entirely to the amount of gas held in solution, and the oleaginous and insipid taste are due to the essential oils and organic matters brought over by the steam.



Our first attempt to purify the water was by forcing a blast of cold air through perforated pipes, situated in the bottom of a tank of known capacity, and a set of experiments conducted but with very unatisfactory results. The bubbles of air rise very rapidly to the surface of the water and in right lines, without seeming to agitate the water at all. Experiments of ten hours durations were made, with the temperatures varying from 75° to 120° Fahr., and the water compressed in a small cylinder (Fig. 2) the measurements being made on the scale (*b*), and each set compared with the standard tension. The standard tension was obtained by subjecting water of fifteen days exposure to the air to a given pressure in the same instrument, and the deflection of the lever registered at one (1). The others were, consequently, in fractions of this unit.

Table A is the result of this set of experiments.

TABLE A.

By a blast of air directed through the water.

Temperature of water, Fahr.	75	80	85	90	95	100	105	110	115	120
Temperature of air.	68·43	68·104	67·98	68·112	68·181	67·875	68·17	68·645	68·	68·3
Compression of water compar'd with that of saturated water.	0·5625	0·4820	0·470	0·375	0.315	0·2812	0·2105	0·190	0·1555	0·0927

From these experiments it is evident that the nearer the temperatures of the air and water approach each other, the more readily they combine. It is equally evident that, with such apparatus, it is impossible to retain them at the same temperature long enough to determine the time required for saturation.

A fountain (fig. 5) was then constructed which injected the water in a spray, the pressure inside being kept up by means of a pump. Much time was consumed in making a proper nozzle, and it was demonstrated at the very first trial that the firmer the spray be divided the more rapid would be the absorption of gas.

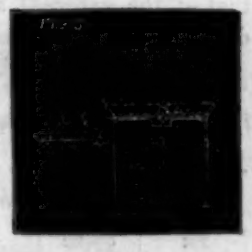
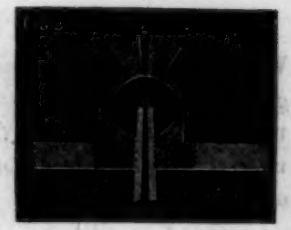


Fig. 3 represents an enlarged view of the nozzle adopted, and one with which the following experiments were made: The water passes through the nozzle *a*, inducing a current of air or other gas through the openings *bb'*, issuing through the opening *c* in a beautiful spray, approaching, in fineness, a mist.



The saturated water was removed from the fountain by being displaced by mercury, it was then collected in a florence flask, the gases expelled by heat and collected in the metric glass, Fig. 4.

The gases were conveyed through the pipe *a* into the glass metric tube *b*, the weight of which was balanced by the cord running over the pulley *p* to the conical pulley *c*, and to the weight *w*. The object of this system of weights and pulleys was to maintain a pressure inside the tube, equal always to that of the external atmosphere, to eliminate, as far as possible, the errors that creep into calculations from experiments made under constantly varying pressures and temperatures.

The Absorption of Air was completed after three hours and a half, the water giving the same compression as water of fifteen days exposure. Experiments were then made with varying temperatures,

the time required to dissolve the gases increasing almost directly with the temperatures. Our attention was then directed to the

ABSORPTION OF OTHER GASES.

The glass shade over the fountain (fig. 5) was filled with the gas under investigation, the temperature and pressure being the same as that of the external atmosphere at the time the gases were withdrawn for measurement.

The same metric tube was used as before.

VOLUMES OF GASES DISSOLVED IN THE UNIT VOLUME OF WATER.

Carbonic Acid	Oxygen	Nitrogen	Sulphuretted Hydrogen	Carbonic Oxide	Marsh Gas	Nitrous Oxide
1·57	0·04092	·0255	3·1435	0·0327	·0543	1·3052

The above table gives the amount of gases soluble in pure water. Water, after dissolving four hundred times its volume of ammoniacal gas, seizes its normal volume of any other gas and absorbs it as readily as if not already impregnated. But the quantity of oxygen necessary to oxidize organic matter in water, is much greater when other gases are present.

RAIN WATER.

The quantity of gases dissolved in rain water was found, by Peligot, to be twenty-five cubic centimetres per litre, or 6·10699 cubic inches per 61·74 cubic inches = 2·47 per cent. of gas. The ratio of absorbed oxygen to nitrogen is greater by volume than in air, on account of the greater solubility of oxygen in water.

Peligot has given the following analysis, by measure:

Atmosphere.		Gases in Rain Water.	
Oxygen .	20·81	Oxygen	31·20
Nitrogen .	79·21	Nitrogen	66·40
		Carbonic anhydride	2·40
	100·02		100·00

Rain water also contains nitric acid and ammonia, and sometimes nitrous acid.

Sulphurous acid is often found in the rain falling in or near manufacturing towns.

All liquids and solids absorb or condense on their surfaces, and in their pores, certain definite quantities of every gaseous body with which

they are placed in contact. The quantity of gases thus absorbed depends on the properties, both physical and chemical, of the bodies brought together, and on the temperature and pressure under which the absorption takes place. Charcoal is a powerful absorbant of oxygen, taking it freely from the atmosphere and liberating nearly all of the nitrogen, for which it has but little affinity.

ON THE ORGANIC MATTER CONTAINED IN WATER.

Surgeon Woods, U. S. N., of the Mare Island Hospital, kindly furnished us with five specimens of water, distilled at the Hospital, as follows:

(1). Distilled, ærated and filtered through animal charcoal.
(2). Distilled, ærated but not filtered.
(3). Distilled, but neither ærated nor filtered.
(4). Distilled, filtered but not ærated.
(5). Salt water, used in the still.

The ærating apparatus was an air-injector, placed in and forming part of the steam pipe, connecting the boiler and condenser.

The filterer was a double return column, the water passing through both, but its velocity, depending on the difference of heights of water in the two columns, was very slow. By such a filterer water is much more effectively deprived of any solid matter held in suspension than by any other form.

The salt water, which was the first taken in consideration, is essentially a chlorinated alkaline mineral water. The saline contents were chiefly sodic, magnesic, potassic and calcic chlorides and sulphates. The organic constituents consisted of a number of very beautiful spores, which gradually develop and produce a very beautiful flower. These flowers are rich in color and luxurious in the quantity, and arrangement of their tints.

We are indebted to Dr. Burgess, of San Francisco, for the use of an admirable microscope of very high power and elegant construction, and for the assistance that gentleman afforded us in our microscopic investigations.

Each specimen was subjected to a careful examination under a quarter inch object glass, before and after exposure to the light, without any discovery in any of those specimens that had been either filtered or ærated. It is easily understood how spores may be removed by filtration, but it is difficult to believe that they could be completely oxidized by any process of æration.

Seven different specimens, treated with pure chrystalline sugar, gelatin, creatin and gum arabic, developed no germs; while in those specimens which were unfiltered and unærated, a single day was sufficient to develop germs, when exposed to the light.

Having failed to develop either spores or animalculæ in the ærated or filtered water, our attention was given entirely to specimens Nos. 3 and 5, namely, the unfiltered and unærated distilled water, and the salt water from which specimen No. 3 was distilled.

After twenty-four hours exposure to light, (in a closed phial) No. 3 showed a small number of germs, scattered about, and of very different sizes and colors.

By treating with crystalline sugar they collected together like bunches of grapes, their colors gradually assuming the same shade. By further exposure to the light they developed into spores and gradually into beautiful flowers, exactly the same as those in the mother salt water, except that the tissue was more delicate and transparent. Finally the same stalks developed, put forth into tiny branches, produced the same flowers as in the sea water, but retained the delicate transparancy which could not be found in any of the salt water tissue. Day after day a drop of each was examined under the microscope, and while the total quantity of matter in the salt water seemed to remain constant, that in the distilled specimen increased rapidly, until, after a few weeks, shreds and clusters of it could be seen with the naked eye in every part of the phial. A few grains of potassic permanganate was introduced into the water in this state, which rapidly oxidized the tissue and precipitated quantities of putrid fungi, which, when received under a quarter-inch object-glass, presented a jelly-like appearance.

After a few days of additional exposure to the sun, spores again made their appearance, developed, ripened and produced the same flower as before, but this time darker and more dense even than those produced by the salt water.

The following is copied from the British *Chemical Journal*, Vol. XXI, being a lecture by Dr. Frankland, F. R. S., to the Association.

ON THE DETERMINATION OF THE AMOUNT OF OXYGEN NECESSARY TO OXIDIZE THE ORGANIC MATTER IN WATER.

"By the addition of known weights of different organic substances to equal volumes of pure distilled water, the latter was artificially

contaminated with a known proportion of each kind of organic matter. Every sample of water so contaminated was made to contain three (3) parts of organic matter in 100,000. The amount of oxygen which this organic matter abstracted from potassic-permanganate was first carefully ascertained, and then the actual amount of organic matter in the water was calculated on the assumption that eight (8) parts by weight of organic matter consumed one (1) part by weight of the permanganate.

"The same test was also applied to another sample of distilled water, from which all organic matter was carefully excluded, but to each 100,000 parts of which three parts of sodic nitrate were added. The importance of this experiment will be evident when it is remembered how frequently nitrates are present in potable waters. The amount of oxygen consumed was determined for two different times, viz.: First, for a period, at the end of which the acidulated and contaminated water remained tainted with the permanganate for ten (10) minutes after the addition of the latter, and secondly, for a period of six hours, during the whole of which time the permanganate was present in excess. The results are contained in the following table, where they are compared with the known amounts of organic matter present, and the known amount of oxygen which that organic matter would require for its complete oxidation :

1	2	3	4	5	6	7
Name of substance, three parts of which were contained in 100·000 parts of water.	Oxygen absorbed in ten minutes	Oxygen absorbed in six hours.	Oxygen required to oxidize organic matter in water (calculated)	Amount of organic matter present (calculated from column 2.)	Amount of organic matter present (calculated from column 3.)	Amou't of organic matter actually present
Gum arabic	0·0102	0·0350	3·55	0·082	0·280	3·
Sugar cane	·0064	·0152	3·37	·051	·111	3·
Starch	·0142	·0302	3·55	·114	·241	3.
Alcohol	0·0093	·0164	6·26	·074	·1s1	3·
Creatin	·0080	·0172	6·59	·064	·138	3·
Gelatin	0·0792	·0836	6·76	·634	1·469	3·
Urea	·0092	·0119	6·40	·074	·095	3·
Hippuric aric	·0328	·0600	5·90	·262	·480	3·
Oxalic acid (crystalised)	·3747	.375	0·38	2·998	3·000	3·
Sodic acid	·691	·6913	0·00	5·521	5·530	0·

From this table it is seen that of the nine kinds of organic material operated upon, only one was completely oxidized by potassic permanganate, even after the lapse of six hours; whilst it will be remarked that urea, hippuric acid and creatin—three organic sub-

stances likely be to present in water recently contaminated with sewage—suffer an oxidation which only reaches $\frac{1}{50}$ of complete oxidation; whilst if the attempt be made to calculate the amount of these substances present in the water, from the quantity of oxygen so absorbed, instead of finding three (3) parts in each 100,000 we obtain only 0·138 part of creatin, 0·095 part of urea and 0·480 of hippuric acid."

THEORETICAL VIEWS.

From the experiments of Dr. Frankland, and those made by ourselves, there is but little doubt that the unoxidized condition of the organic matter after the specified period of duration, was due to imperfect diffusion; the degree of the oxidation of most of the substances depending upon the time they remained in contact with the permanganate.

But in the sample of ærated water (No. 1) though it had not been filtered, there could not be found a trace of any organic matter. It is popularly believed that the organic matter brought over with the steam is thoroughly oxidized by its contact with the atmospheric air, which is mixed with the steam and has the same temperature. By such means there is probably a most perfect diffusion of all the gases of the atmosphere with the steam and with each other, and being assisted by temperature, little or nothing escapes oxidation.

Bibliographical Notices.

Half Hours with Modern Scientists. Charles C. Chatfield & Co., New Haven. 1871.

The publishers have very judiciously issued, in book form, the first five numbers of their "University Scientific Series," and will doubtless be amply repaid for their experiment. The volume contains lectures and essays from Huxley, Barker, Cope and Tyndall.

The matter of the discourses needs no comment. They have already received the heartiest tribute of praise which is their due. They have inaugurated almost a new era in the influence they have exerted upon popular thought. They have served the great purpose of breaking down the barrier of exclusiveness with which men of science had hedged themselves about. They have presented the aspirations and strivings of physical investigators in terms free from technicality and

characterized by a diction forcible and elegant, and by clothing the magnificent results achieved by modern thinkers with all the charms of romance, have awakened an interest and sympathy in the public mind, which, as it tends towards the universal diffusion of the truths and methods of science, and an intelligent appreciation of her claims for support and encouragement, affords the happiest auguries for the future.

A Practical Guide for the manufacture of Metallic Alloys, comprising their Chemical and Physical Properties, with their Preparations, Composition and Uses. Translated from the French of A. Geuttier by A. A. Fesquet. Philadelphia, Henry Carey Baird, Industrial Publisher. 1872.

The work above named contains in brief space a compilation of nearly everything that is known concerning the chemical and physical properties of alloys, adapted to the most varied industrial purposes. Besides this general matter, quite an amount of special information of just that kind which alone is available and serviceable to the practical metallurgist is given, concerning the composition, mode of preparation and uses of a great number of alloys. The numerous critical observations of the author upon the relative merits of various compositions for special purposes in the arts, founded partly upon his own observations and experimental researches—for which his position would afford him ample opportunity—and partly upon the practical experience of others, will be found to be of great value to experimenters in this branch of technology.

The Civil Engineer's Pocket Book. By John C. Trautwine. Claxton, Remsen & Haffelfinger, 819 and 821 Market street, Philadelphia.

We have here a volume which simplifies the abtrusities of mechanical science, and gives rules and examples at once "susceptible of complete and satisfactory explanation to any person who *really* possesses only elementary knowledge of arithmetic and natural philosophy." Let every mechanic rejoice that we have at last a book which presents the knowledge he wants in *intelligible language.*

It contains a treatise on Mensuration amply illustrated, a marvel of clearness and compactness, and includes a table of spherical surfaces and solidities from $\frac{1}{64}$ of an inch up to 100 inches diameter, advancing with no greater fraction than one-eighth of an inch. Synopses of

Arithmetic, Geometry and plane Trigonometry, extended tables of squares and cubes and corresponding roots of numbers from 1 to 1000 and roots to 10,000.

Weights and measures with numerous decimal equivalents, translating at once the units of any measure into equal values of every other.

Tables and Rules relating to surveying, with description and manipulation of field engineering instruments.

To the very important subject of the "strength of materials," 69 pages are devoted, and in this liberal allotment of space we find full and clear expositions of Strength and Strain, disposition of materials, Joints and method of Joining, and in fact the essential bearings to every day practice of this department of engineering. We have not seen together in any work so much matter in the shape of rules and formulæ, which can be so readily understood and applied. This has also the additional advantage of presenting the later experiments and deductions.

Sixty-six pages are given to trusses and trestles, with ample illustrations, elucidations and calculations. Forty-six pages to stone work, including foundations, retaining walls and stone bridges. Two hundred and fifty-eight pages principally to the weights of metals and products, strengths of chains and ropes, specific gravity, rails and joints, turnouts and turntables and apparatus therefor, railroads and earthwork, the mechanics of force in rigid bodies—an admirable chapter—mortar, brick, cement and concrete, hydraulics and hydrostatics, dams, suspension bridges, friction, traction and animal power, and after these a glossary of terms used in the arts; finally a very clear and complete index, making in all 645 pages.

Next in importance to having the thing wanted, is the means of finding it promptly, and the index to this volume is one of the best. This, like the index of the "Ordinance Manual," has the leading subject set in bolder type and strikes the eye at once.

In this feature, so often slighted, in the typographical execution and make up of the work, particularly in the abundance of large and eminently useful fact, compressed into smallest space, Mr. Trautwine's Engineers Pocket Book must take highest rank.

J. H. C.

Obituary.—ADOLPH STRECKER died on the 7th of November at Wurzburg in Bavaria, after a short illness. His fame as a Chemist is not so widely known in America as in Europe, though all who are familiar with the literature of chemistry have heard of him.

Prof. Strecker was a native of Darmstadt, whence Liebig, Kekulé and so many of the celebrated scientists of Germany came. At an early age he entered the University at Giessen, devoting himself to mathematics, but afterwards took up the study of chemistry with Liebig. He gained his degree of Dr. in Philosophy, and then was appointed private assistant to Liebig and afterwards *Privat Docent.* Here he was associated with Fresenius, Merck, Fleitmann, Wetherill and many others whose reputations are so great as workers in science. Receiving a call to Christiana as Professor, he left Germany for a number of years, but was busily engaged in work which aided the development of the newer chemistry. From Christiana he went to Tübingen in Württemberg, where he remained nearly nine years, during most of which time he directed the *Jahresbericht* and *Liebig's* Journal, aided in the compilation of the "*Handwörterbuch der Chemie,*" and published seven or eight editions of his Manuals of Organic and Inorganic Chemistry. These latter are text books to the elementary lectures in all the German Universities, and though not translated into English, are used in Russia and France. Prof. Strecker received last year two calls, one to Cincinnati with a salary of $5,000, and another to Wurzburg, to succeed Prof. Sherer, who had died there. This latter appointment he accepted, and removed thither, believing that he could work more industriously. Some years ago, whilst experimenting on Prof. Crooke's new metal, Thallium, Prof. Strecker was injured by noxious vapors, and suffered great privations and agony, and finally endured an operation, but without any permanent relief. Doubtless his early demise is owing to the disease contracted by this misfortune, for he died of asthma, and the writer has often seen him lecturing with his throat and head tied up, so that only one eye was visible, inflammation of the acutest kind afterwards overcoming him for days. Unassuming but dignified, energetic and unceasing in his labors, Prof. Strecker's short career has been crowded with distinction. His labors are the means of instruction to thousands, and the writer having worked under his supervision knows how sadly his loss will be felt by all students in chemistry.

Philadelphia, Nov. 25, 1871. F. H. R.

Franklin Institute.

Proceedings of the Stated Meeting, Sept. 20th, 1871.

The meeting was called to order by the President, Mr. Coleman Sellers.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers and reported that, at their stated meeting held September 13th, donations to the library were received from

The Royal Astronomical and Geographical Societies of London. The Manchester Steam Users Association of Manchester, England. The Austrian Society of Engineers and Architects, Vienna. From the American Philosophical Society, Philadelphia. The Smithsonian Institution, at Washington. The U. S. Coast Survey, Washington, D. C. And from Prof. J. E. Nourse, U. S. N.

The Committee appointed to investigate the subject of the Horse-power of Steam Boilers reported progress.

The Secretary then read his Monthly Report on Novelties in Science and the Mechanic Arts, after which the meeting adjourned.

WILLIAM H. WAHL, *Secretary.*

Proceedings of the Stated Meeting, Oct. 18th, 1871.

The meeting was called to order by the President, Mr. Coleman Sellers.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers and reported that, at their last meeting held October 11th, donations to the library were received from

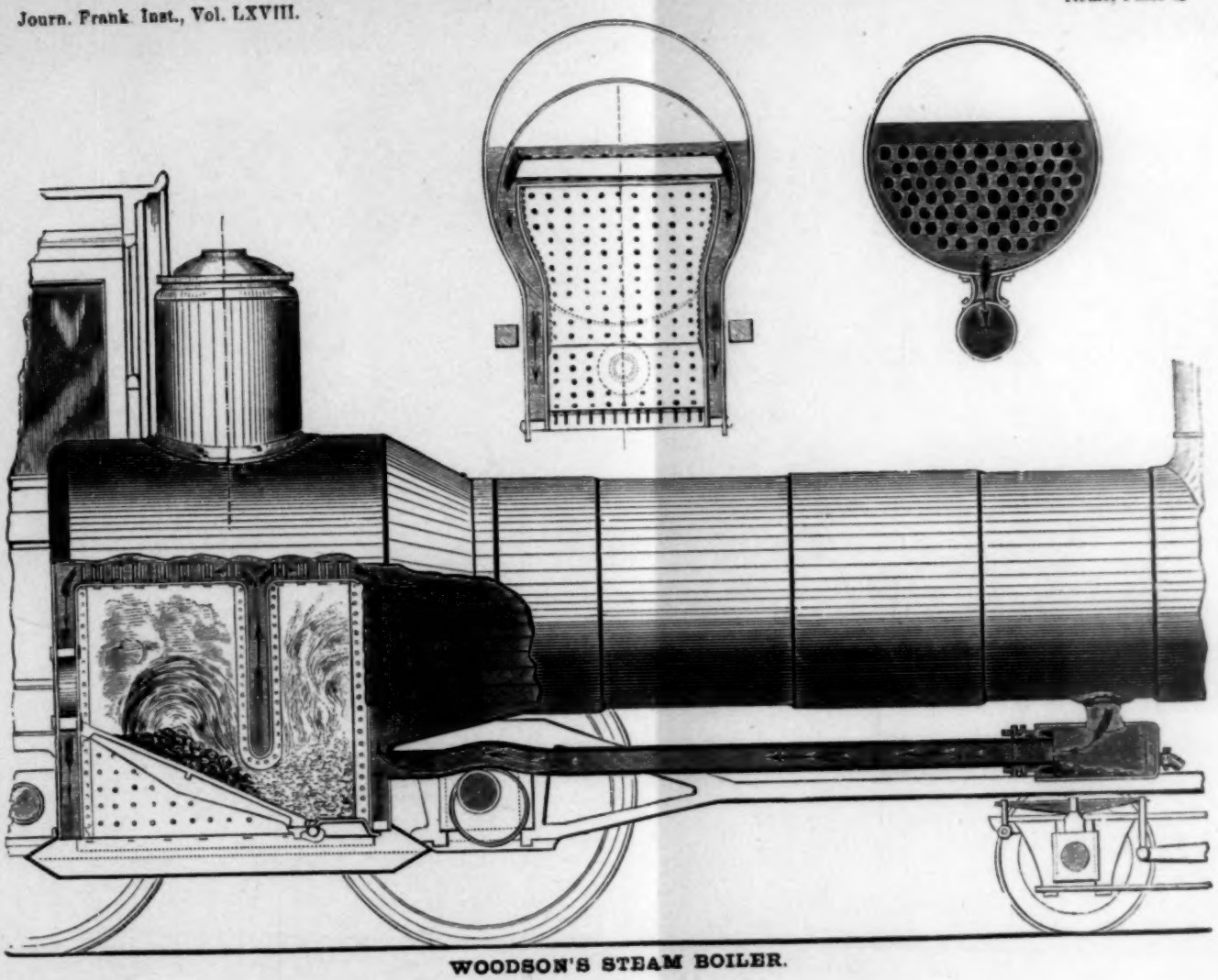
The New York Canal Commissioners. Georgia Historical Society. And the Department of the Interior, Washington.

The Committee appointed to investigate the Horse-power of Steam Boilers reported progress and were continued.

Under the head of new business, the President announced that the Board of Managers had approved a resolution of the "Committee on Science and the Arts," awarding the Elliott Cresson Medal to Mr. B. C. Tilghman, for the discovery of a process of cutting and engraving hard substances.

The Secretary then read his Monthly Report on Science and the Arts, after which the meeting adjourned.

WILLIAM H. WAHL, *Secretary.*



WOODSON'S STEAM BOILER.